

LA CARATTERIZZAZIONE CHIMICA DEL PARTICOLATO ATMOSFERICO

Giornate di studio e approfondimento interagenziale

27- 28 novembre 2023

VI edizione

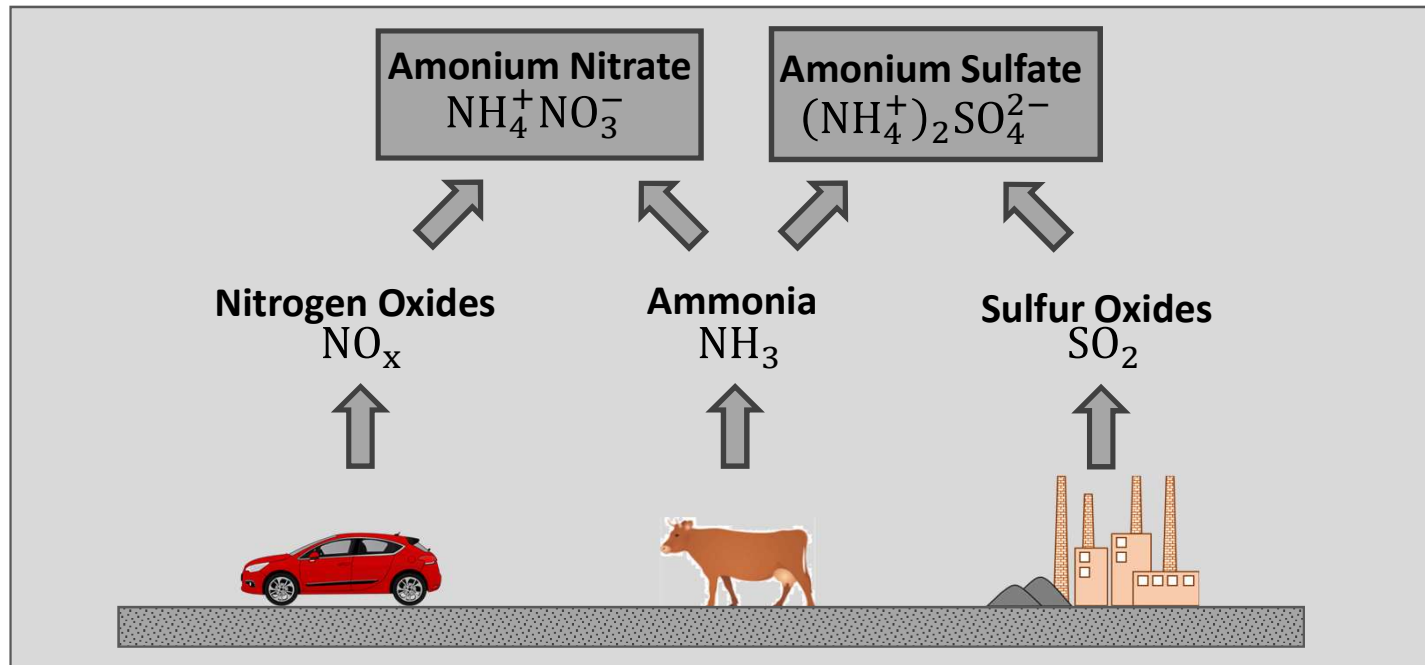
Formation and Reduction of SIA across Europe

Alain Clappier

SIA Formation

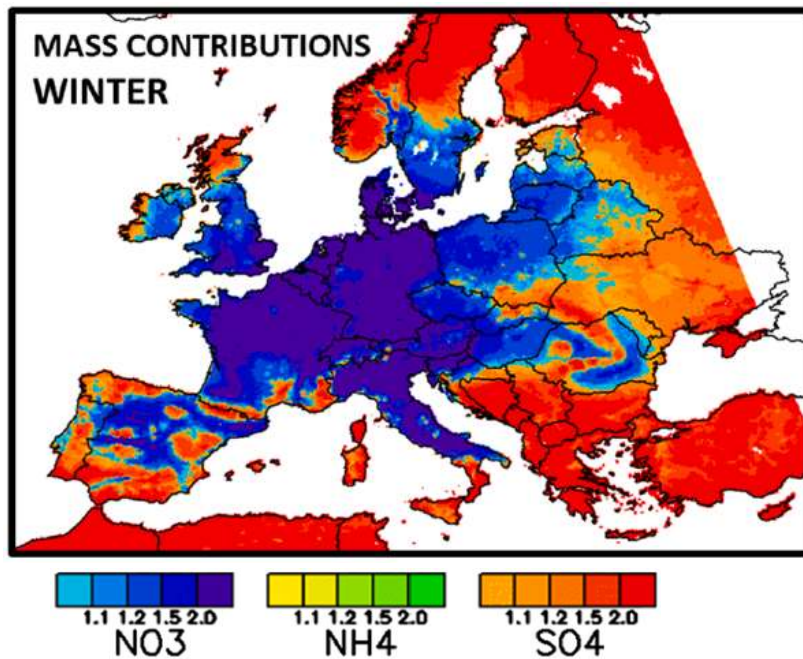
SIA are formed from 3 precursors NH_3 which, with NO_x , gives Ammonium Nitrate $\text{NO}_3^- \text{NH}_4^+$ and with SO_2 gives Ammonium Sulfate $(\text{NH}_4^+)_2 \text{SO}_4^{2-}$.

Which of these precursors should be reduced in priority ?



European Reduction Strategies in Winter

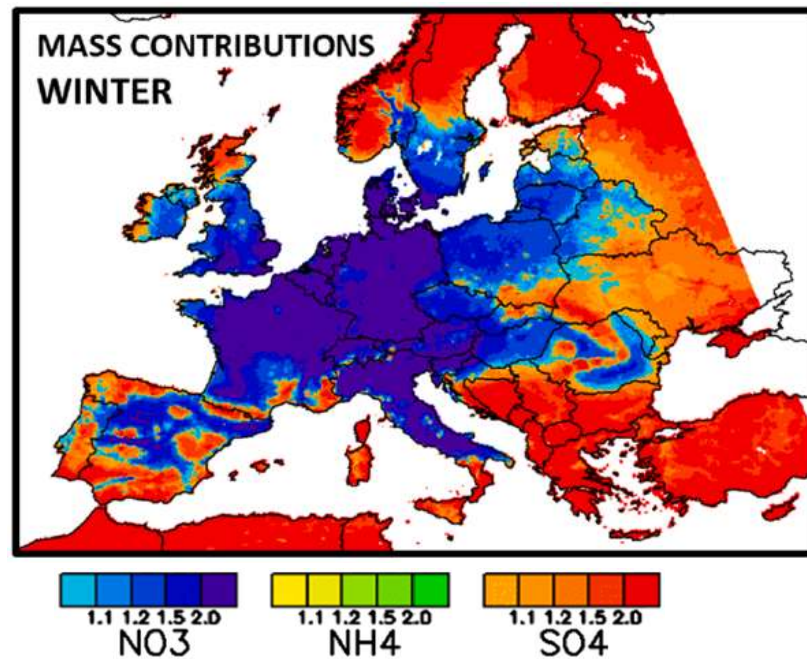
Contributions of each precursor (i.e. mass fraction of nitrate NO_3^- , sulfate SO_4^{2-} and ammonium NH_4^+)



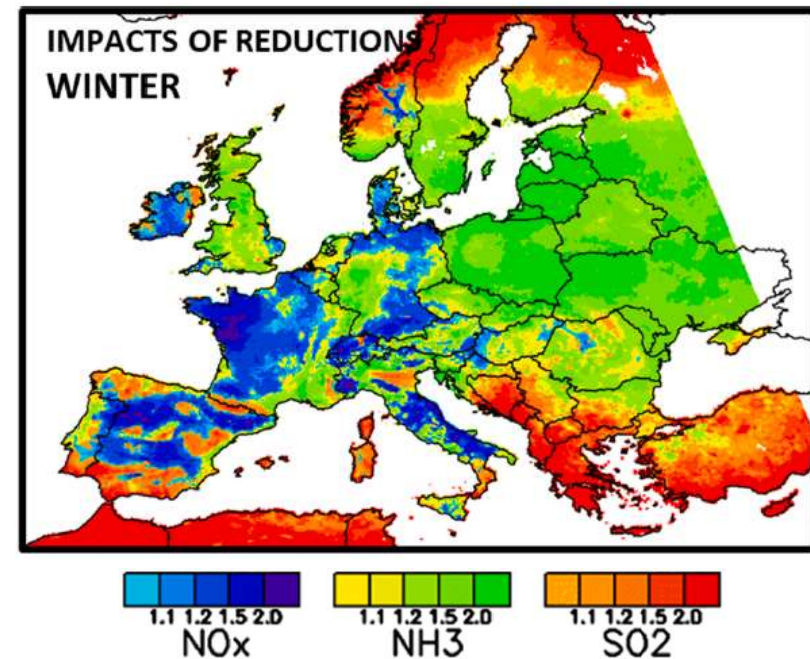
In winter the mass fractions of nitrate NO_3^- and sulfate SO_4^{2-} are the largest contributions of SIA formation.

European Reduction Strategies in Winter

Contributions of each precursor (i.e. mass fraction of nitrate NO_3^- , sulfate SO_4^{2-} and ammonium NH_4^+)

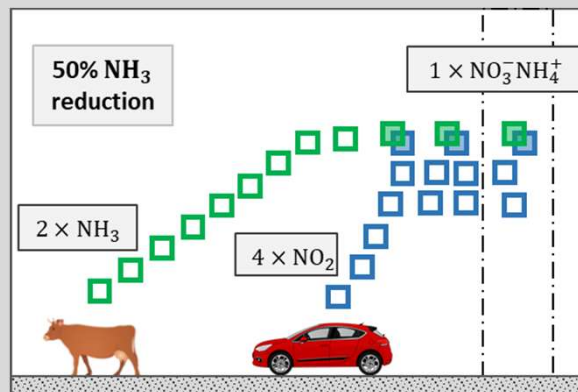
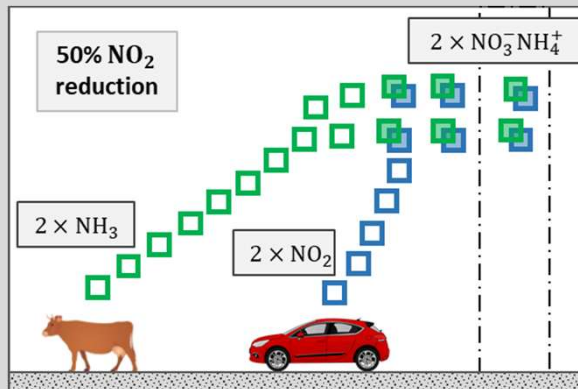
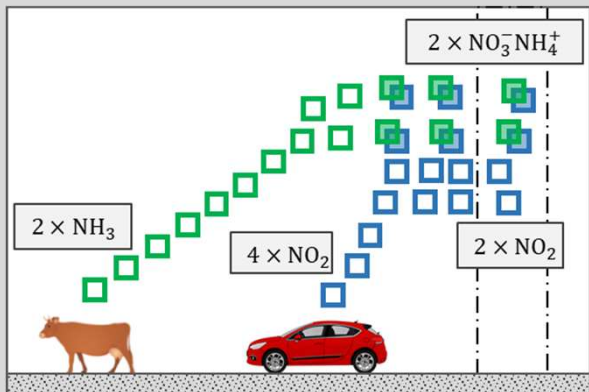
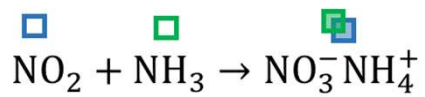


Reduction of 50% of each precursor NO_x , NH_3 and SO_2 independently



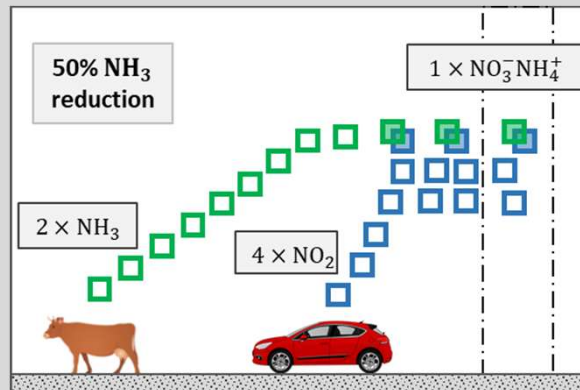
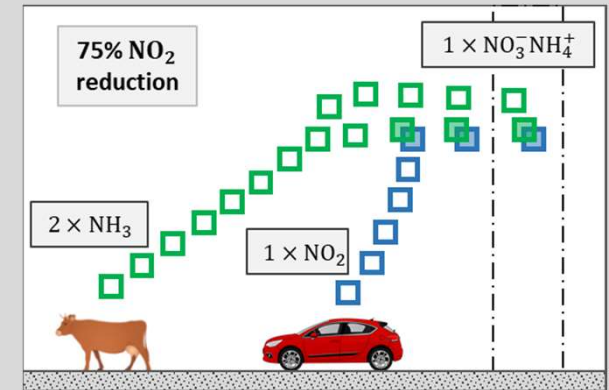
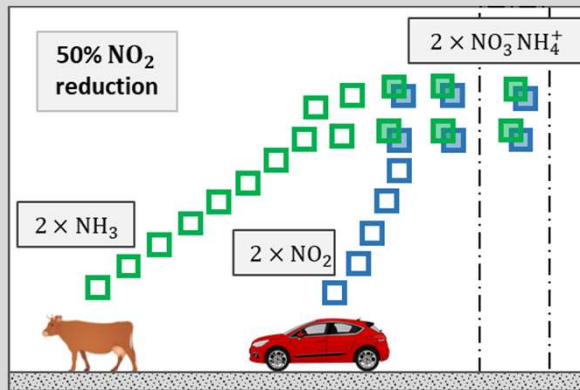
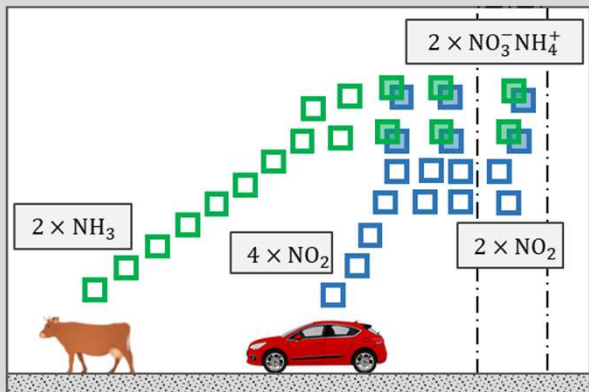
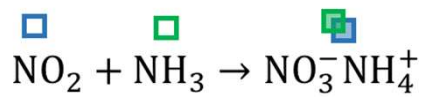
Why, in winter, ammonia NH_3 reductions lead to the most important SIA reductions while the mass fractions of nitrate NO_3^- and sulfate SO_4^{2-} are the largest contributions of SIA formation?

NO₂ v.s. NH₃ Reduction Strategies



When the atmosphere is saturated with NO₂, their reductions are less effective than those of NH₃.

NO₂ v.s. NH₃ Reduction Strategies

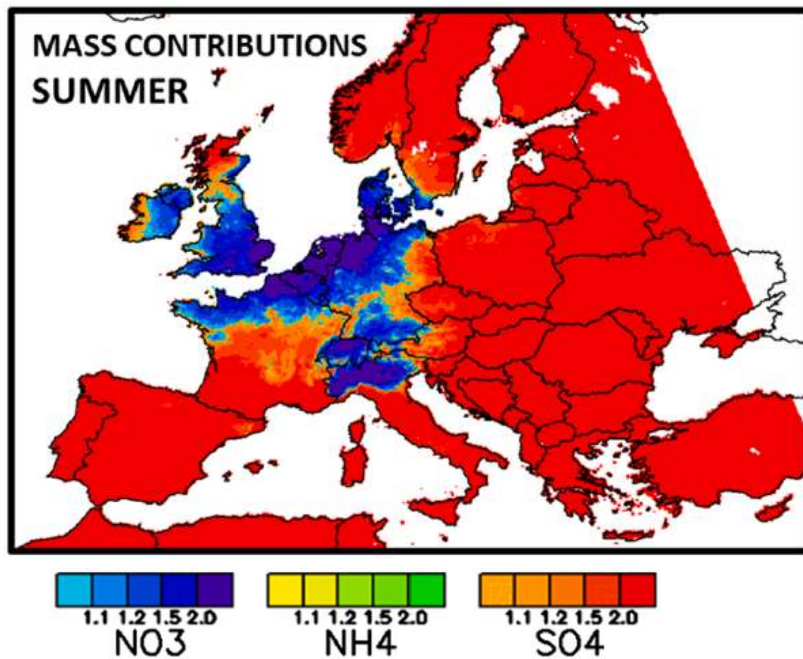


When the atmosphere is saturated with NO₂, their reductions are less effective than those of NH₃.

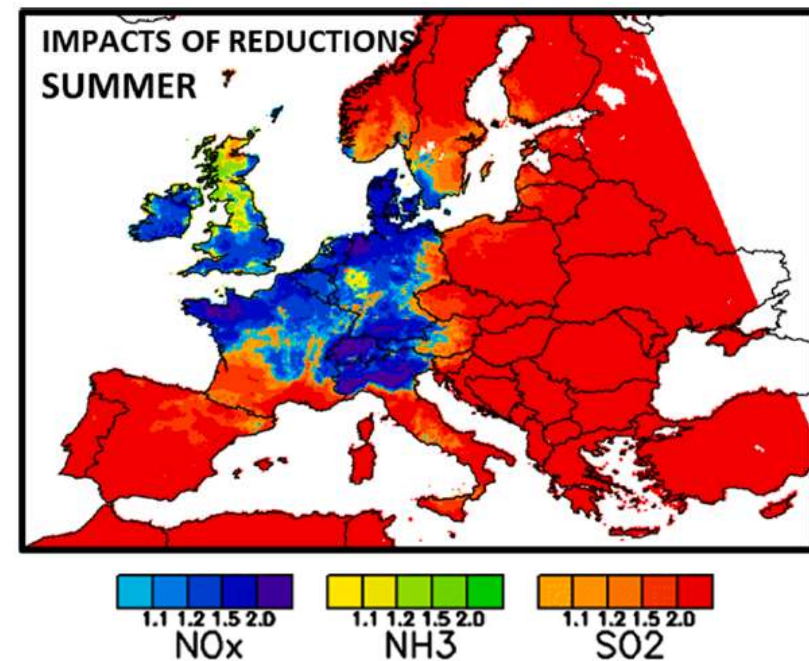
To be effective the NO₂ reductions must exceed a certain threshold.

European Reduction Strategies in Summer

Contributions of each precursor (i.e. mass fraction of nitrate NO_3^- , sulfate SO_4^{2-} and ammonium NH_4^+)



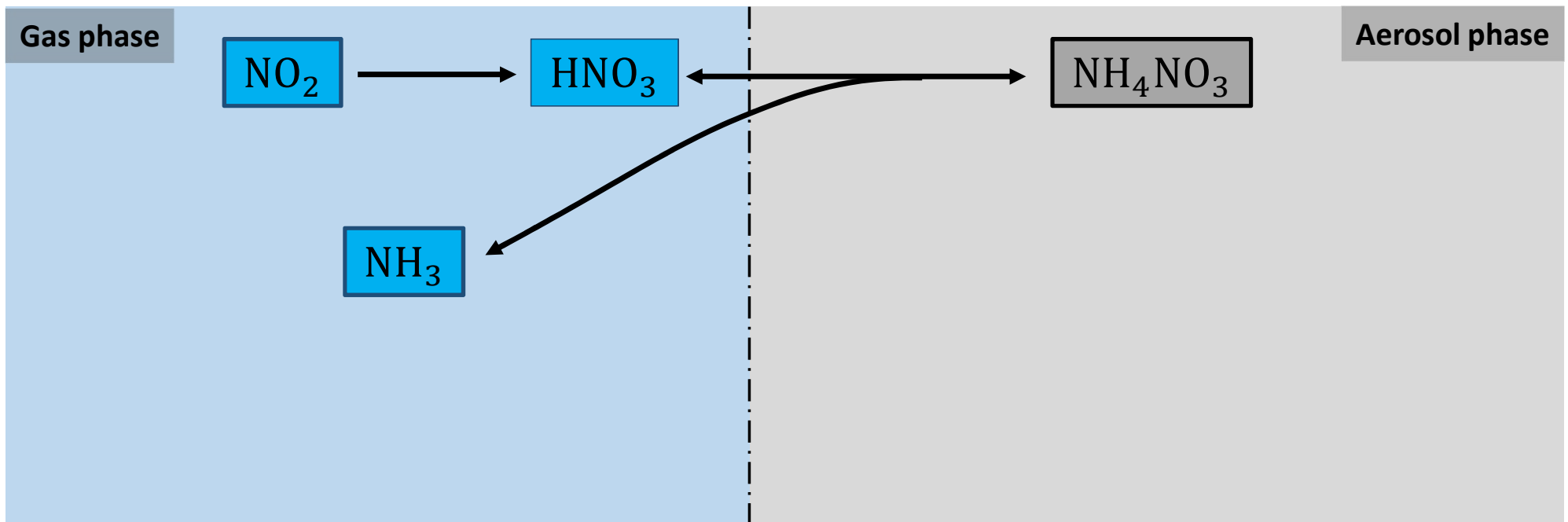
Reduction of 50% of each precursor NO_x , NH_3 and SO_2 independently



Over large areas in summer, SO_2 is the precursor that produces the greatest reductions when the sulfate SO_4^{2-} mass fraction is largest.

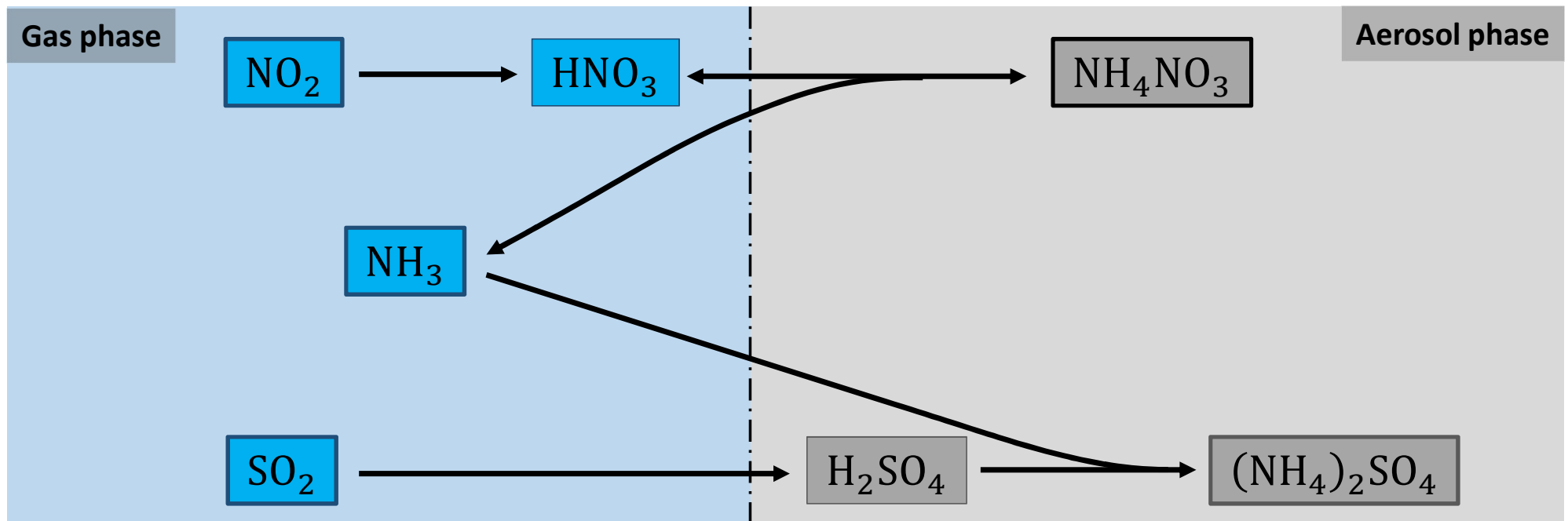
SIA Formation: Ammonium Nitrate

Ammonium nitrate NH_4NO_3 is formed from ammonia NH_3 and nitric acid HNO_3 existing in the gas phase. Ammonia and nitric acid can therefore be limiting factors in nitrate NO_3 formation.



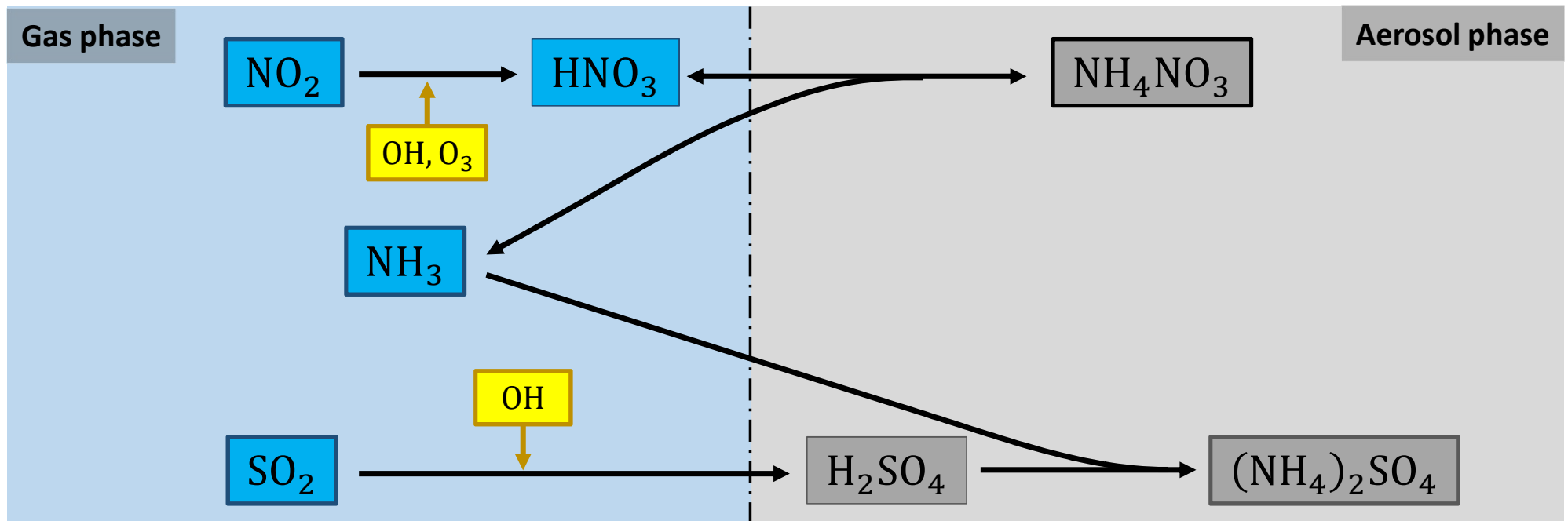
SIA Formation: Ammonium Sulfate

Ammonium nitrate NH_4NO_3 is formed from ammonia NH_3 and nitric acid HNO_3 existing in the gas phase. Ammonia and nitric acid can therefore be limiting factors in nitrate NO_3 formation.



SO_2 has the ability to produce sulfuric acid directly in the aerosol phase. Ammonia NH_3 is therefore not a limiting factor in sulfate SO_4 formation, which does not necessarily require the presence of ammonium NH_4 .

SIA Formation: Atmospheric Oxidation Capacity

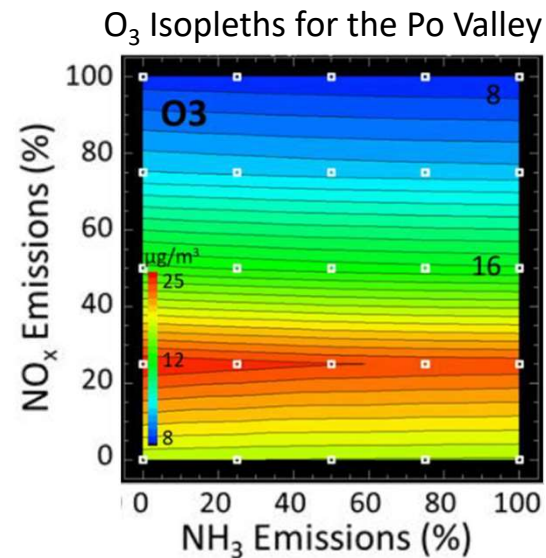
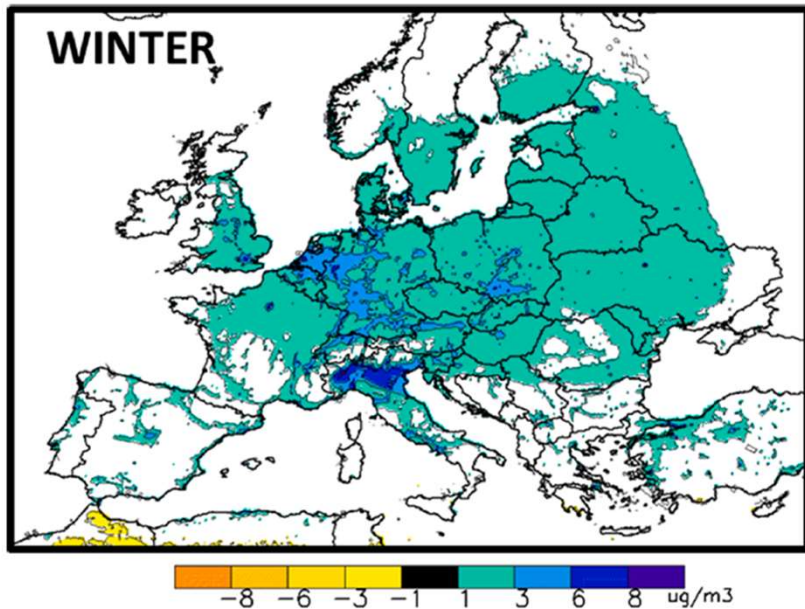


The formation of nitric and sulfuric acids from NO_2 and SO_2 depends on the oxidation capacity of the atmosphere (presence of OH radicals and O_3).

European Reduction Strategies O₃ and PM

In heavily polluted areas, a reduction in NO_x leads to the release of OH radicals and an increase in O₃ which increase the atmospheric oxidation capacity.

ΔO₃ (Scenario – Base Case) for a reduction of 50% of NO_x

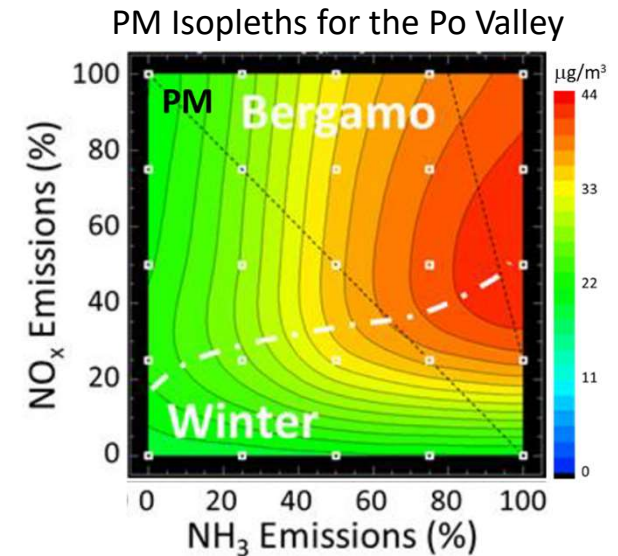
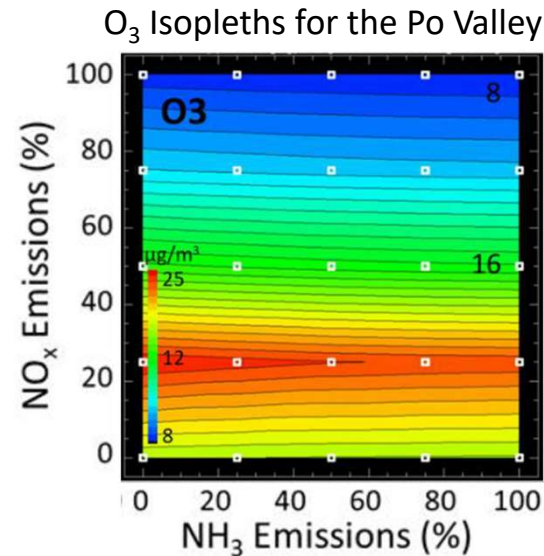
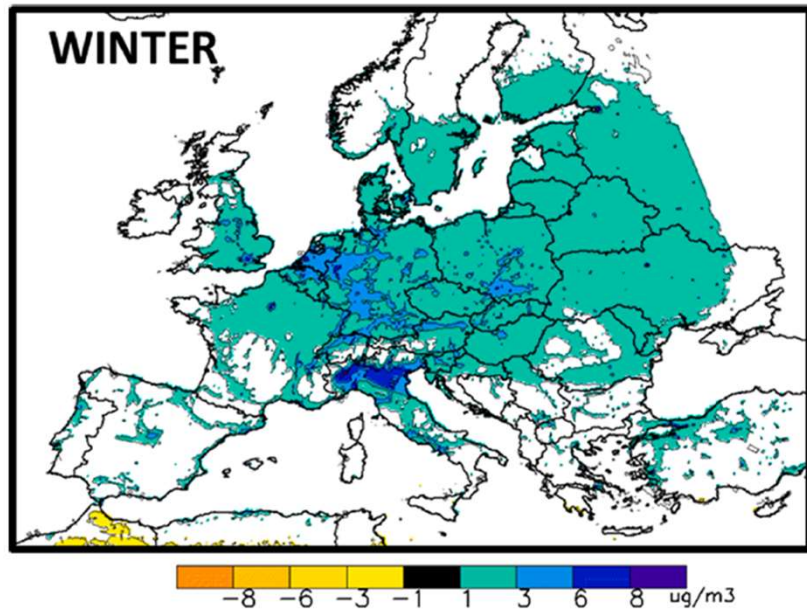


European Reduction Strategies O₃ and PM

In heavily polluted areas, a reduction in NO_x leads to the release of OH radicals and an increase in O₃ which increase the atmospheric oxidation capacity.

In such situation, SIA could also increase.

ΔO_3 (Scenario – Base Case) for a reduction of 50% of NO_x





Grazie per la vostra attenzione