Lecture 11. **Global biogeochemical cycles of nitrogen and oxygen.**

Objectives:
1. Global biogeochemical cycle of nitrogen.
2. Global biogeochemical cycle of oxygen.

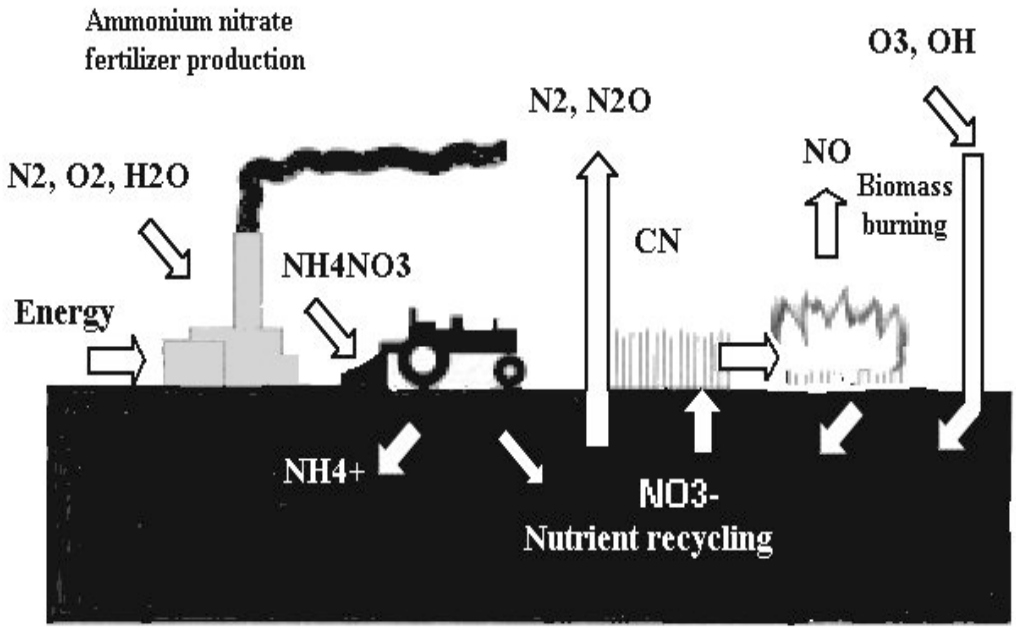
Readings: Turco: p. 301-307; Brimblecombe: p. 23-24, 38 (20-41)

1. Global biogeochemical cycle of nitrogen.

Principal nitrogen compounds in the atmosphere:

N_2 , N_2O, NO, NO_2 , HNO_3, NH_3

Figure 11.1 The elements of the nitrogen cycle accounting for fertilization.



- N_2 is extremely stable chemically and is not involved in the chemistry of the troposphere or stratosphere (except atmospheric conditions with high energy, such as lightning).

- N_2O is colorless gas (referred to as "laughing gas) emitted almost totally by natural sources.

Table 11.1 Estimated sources and sinks of N_2O typical of the last decade (IPCC 1995).

Sources	Range (Tg(N) yr^{-1})	Likely (Tg(N) yr^{-1})
Natural		
Oceans	**1-5**	**3**
Tropical soils:		
wet forest	**2.2-3.7**	**3**
dry savannas	**0.5-2.0**	**1**
Temperate soils:		
forests	**0.1-2.0**	**1**
grasslands	**0.5-2.0**	**1**
Total natural sources	**6-12**	**9**
Anthropogenic		
Cultivated soils	**1.8-5.3**	**3.5**
Biomass burning	**0.2-1.0**	**0.5**
Industrial sources	**0.7-1.8**	**1.3**
Cattle and feedlots	**0.2-0.5**	**0.4**
Total anthropogenic sources	**3.7-7.7**	**5.7**
Total sources	**10-17**	**14.7**
Sinks		
Stratosphere	**9-16**	**12.3**
Soils	**?**	**?**
Total sinks		
Implied total sources (atmospheric increase+total sinks)	**13-20**	**16.2**

- NO_x ($NO + NO_2$) are emitted both by natural and anthropogenic sources.

Table 11.2 Estimated global emissions of NO_x typical of last decade (IPCC 1995).

Sources	Magnitude (Tg(N)/yr.)	Comments
Fossil-fuel combustion	24	Surface sources;>95% NH
Soil release (natural and anthropogenic)	12	Continental surface source
Biomass burning	8	Tropical surface source
Lighting	5	Free troposphere source
NH_3 oxidation	3	Tropospheric source
Aircraft	0.5	6-12 km source; 95% NH
Transport from stratosphere	0.1	Free troposphere source

Reactive nitrogen, denoted NO_y, is defined as the sum of the NO_x and all compounds that are products of the atmospheric oxidation of NO_x (these include nitric acid, HNO_3; nitrous acid, HONO; the nitrate radical, NO_3; dinitrogen pentoxide, N_2O_5; peroxynitric acid, HNO_4; peroxyacetyl nitrate, PAN ($RC(O)OONO_2$).

Typical NO_y concentrations:

in rural areas: 0.07-1 ppb

in the remote troposphere: 1-20 ppb

Mean tropospheric residence time for gaseous NO_y (including HNO_3):

1 to 4 days

NOTE: Because of this relatively short atmospheric lifetime, the major effects of emissions of nitrogen oxides are expected to be local or regional rather than global in nature.

- Ammonia is the primary basic gas in the atmosphere and, after N_2 and N_2O, is the most abundant nitrogen-containing compound in the atmosphere.

Table 11.3 Estimated global ammonia emissions.

Source of Ammonia	Emission (Tg(N) yr^{-1})
Natural	
Wild animals	**2.5**
Vegetation	**5.1**
Ocean	**7.0**
Total natural sources	**14.6**
Anthropogenic	
Dairy cattle	**5.5**
Beef cattle	**8.7**
Pigs	**2.8**
Horses	**1.2**
Sheep/goats	**2.5**
Poultry	**1.3**
Fertilizer	**6.6**
Biomass burning	**2.0**
Total anthropogenic sources	**30.4**
Grand total	**45.0**

Ammonium ions (NH_4^+) are important component of the tropospheric aerosol.

Mean tropospheric residence time for ammonia:

about 10 days (because NH_3 is readily absorbed by surfaces such as water and soil)

- Nitrogen fixation refers to the chemical conversion of N2 to any other nitrogen compound. For instance, some microorganisms are capable of converting N2 ammonia and ammonium ion.

2. Global biogeochemical cycle of oxygen.

Principal oxygen compound in the atmosphere:

O_2 , O_3

- The source of oxygen in the atmosphere reservoir is CO_2: CO_2 + H2O under sunlight conditions (photosynthesis) produces oxygen and organic compound.

Figure 11.2 The partitioning of oxygen between the atmosphere and the biosphere, and the role of carbon burial in free oxygen production (Turco 1997).