Addressing greenhouse gases along the explosives life cycle

By: Geoff Brent

Presented by:

Noel Hsu

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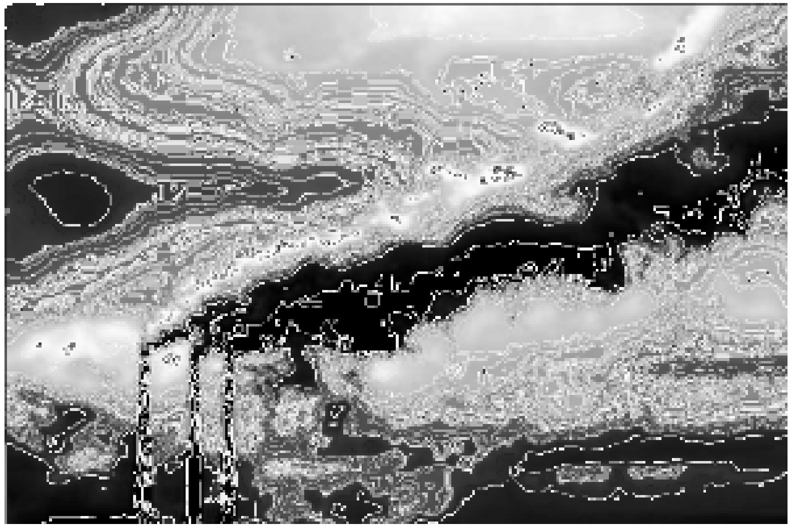
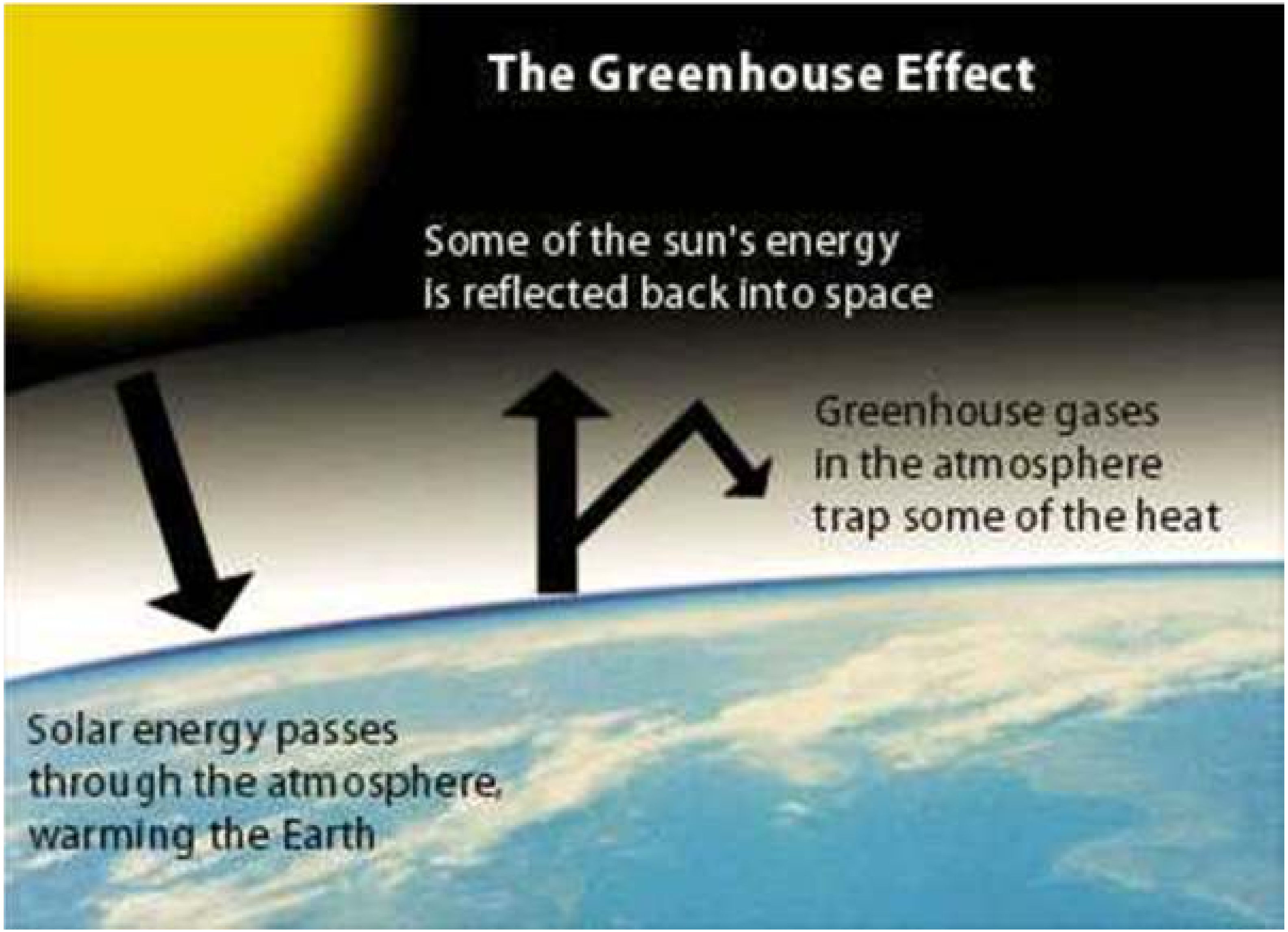
Outline

- The context – GHGs & climate change…
- Explosives life cycle and GHG footprint
- Detonation and GHGs
- Reducing the GHGs in explosives manufacture
- Downstream mining & mineral impacts
- How blasting can make a difference



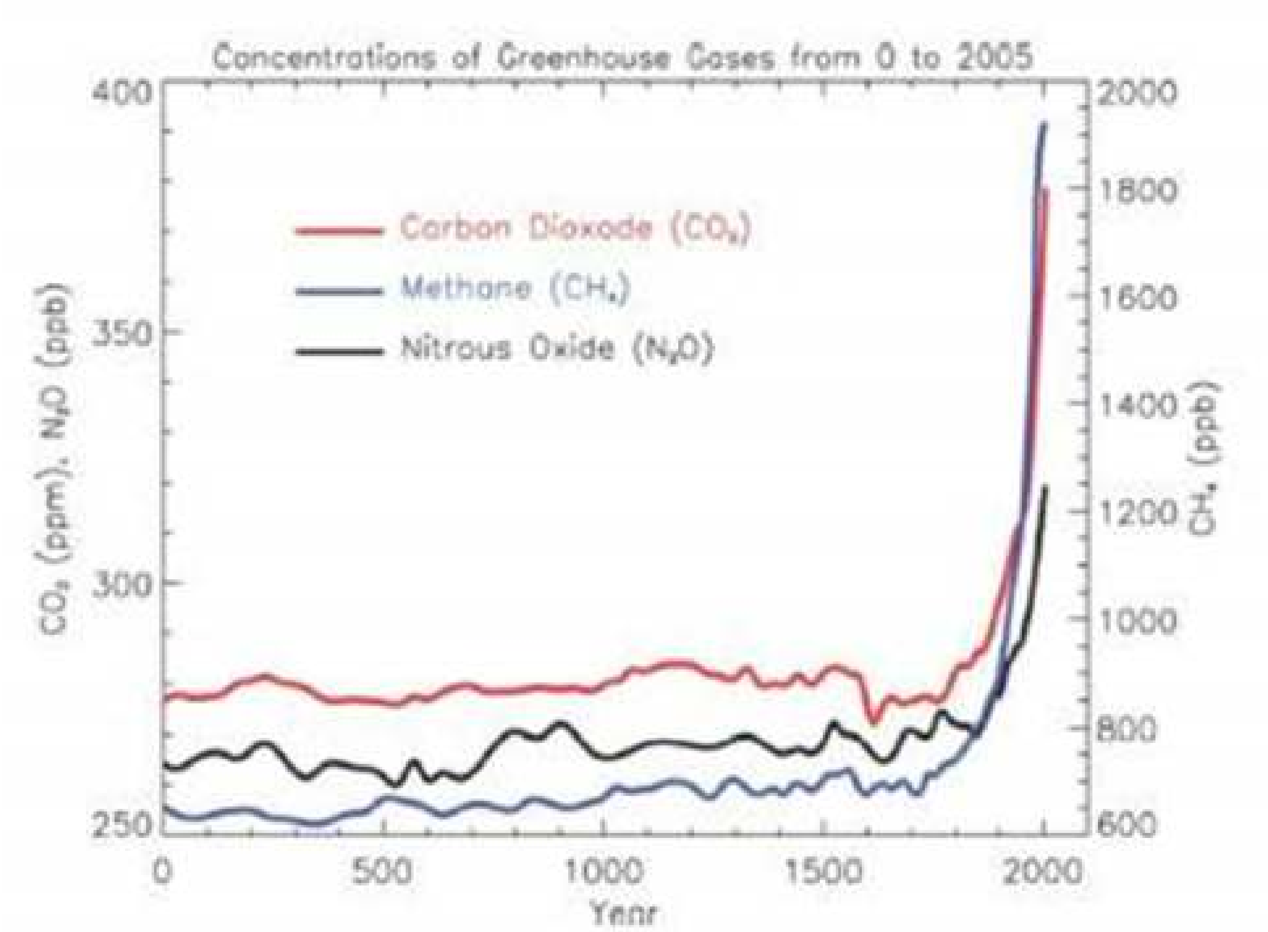
The context - GHGs & climate change



www.environmentalsociety.ca/issues/climate/saskatchewan.html

Greenhouse Gases (GHG)

GHG	Global Warming Potential (GWP)
CO_2	1
CH_4	21
N_2O *(not NOx !)*	310
SF_6	23 900
HFCs	140 - 6 300
Fluorocarbons	6 500 - 9 200



Global Climate Change Impacts in the United States, Thomas R. Karl, Jerry M. Melillo, and Thomas C. Peterson,
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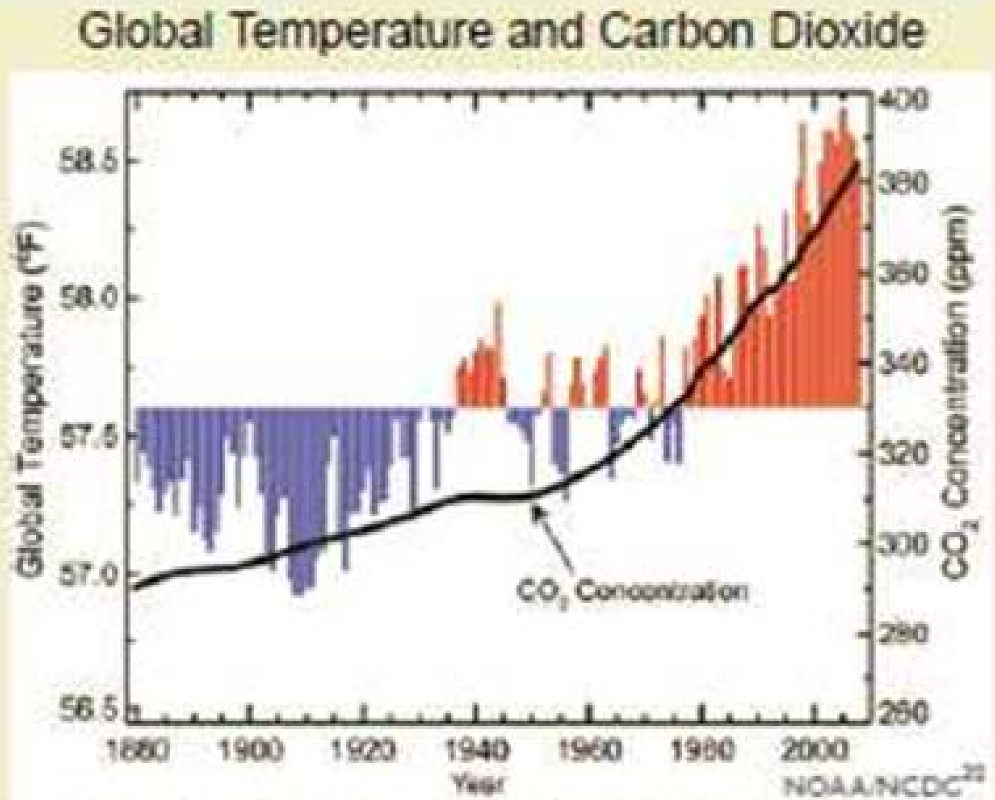


Global annual average temperature (as measured over both land and oceans). Red bars indicate temperatures above and blue bars indicate temperatures below the average temperature for the period 1901-2000. The black line shows atmospheric carbon dioxide (CO_2) concentration in parts per million (ppm). While there is a clear long-term global warming trend, each individual year does not show a temperature increase relative to the previous year, and some years show greater changes than others.[32] These year-to-year fluctuations in temperature are due to natural processes, such as the effects of El Niños, La Niñas, and the eruption of large volcanoes.

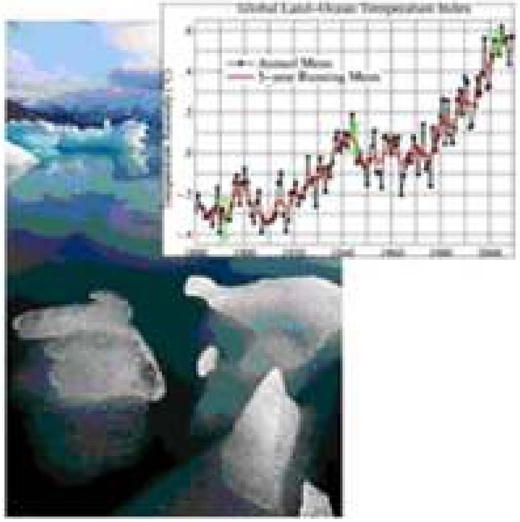
Science NOW UP TO THE MINUTE NEWS FROM SCIENCE

NASA: 2010 Meteorological Year Warmest Ever

by Eli Kintisch on 10 December 2010, 2:44 PM | Permanent Link | 28 Comments

The 2010 meteorological year, which ended on 30 November, was the warmest in NASA's 130-year record, data posted by the agency today shows. Over the oceans as well as on land, the average global temperature for the 12-month period that began last December was 14.65°C. That's 0.65°C warmer than the average global temperature between 1951 and 1980, a period scientists use as a basis for comparison.

ENLARGE IMAGE

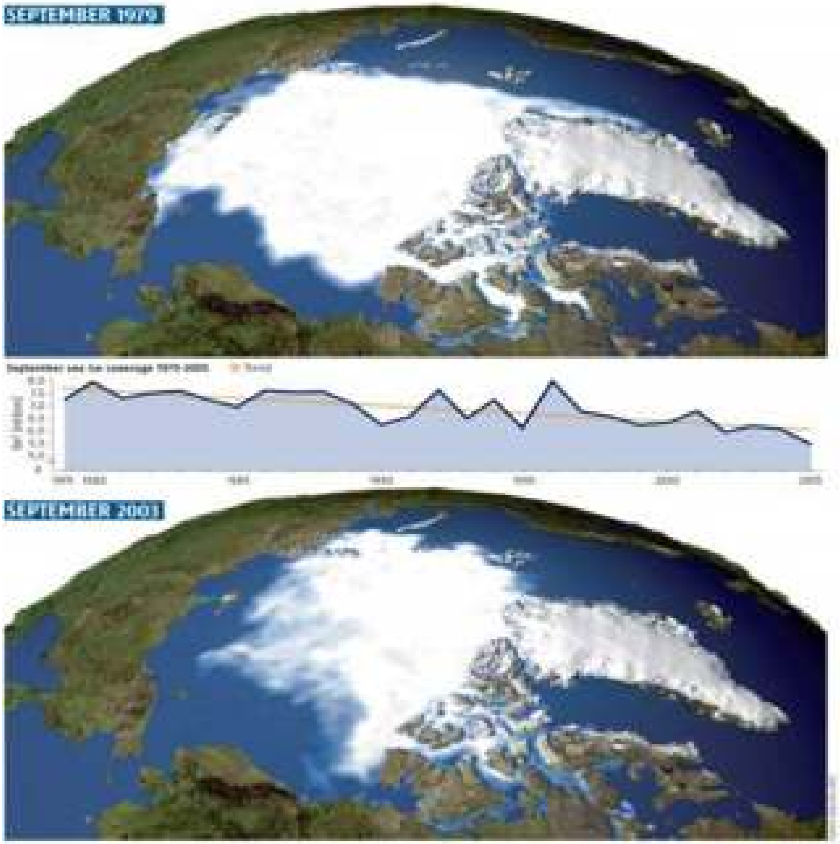


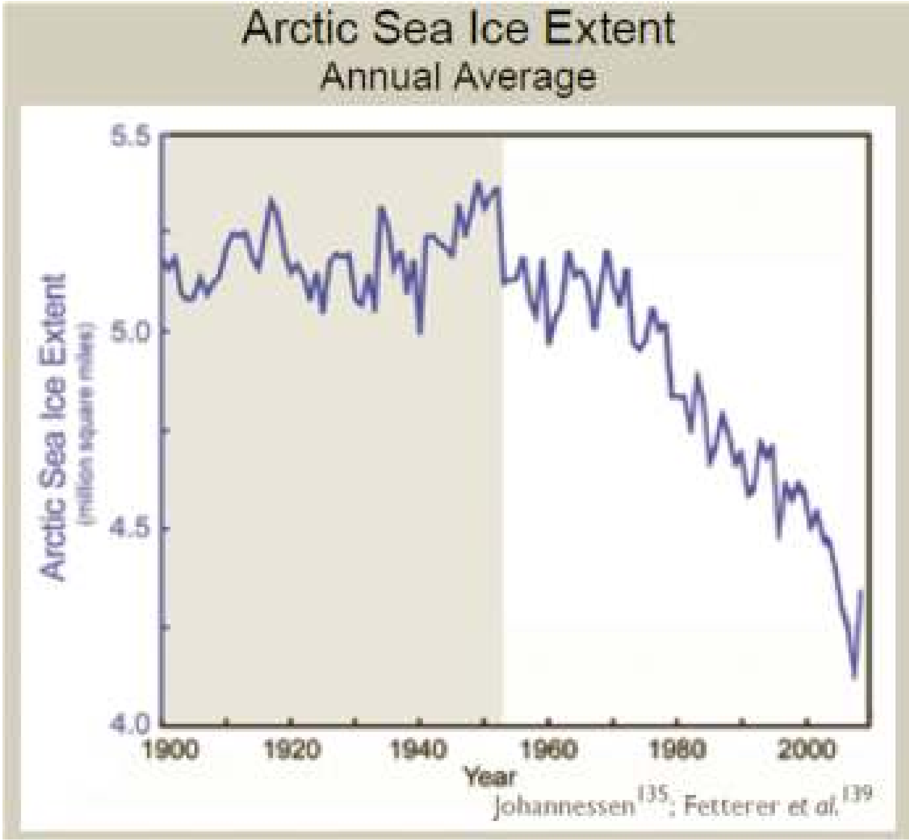
Heating up. New data from NASA show that the global warming trend continues, with 2010 as the hottest year on record (*inset*). Missing Arctic sea ice may be contributing to the warming.

The 2010 meteorological year was slightly warmer than the previous warmest year, the 2005 calendar year, when the average temperature was 14.53°C.

In 2010, temperatures measured over land alone were also the warmest ever, with instruments showing a December-November average of 14.85°C. Combining this warming with above-average ocean temperatures led to the global average of 14.65°C.

Sea ice





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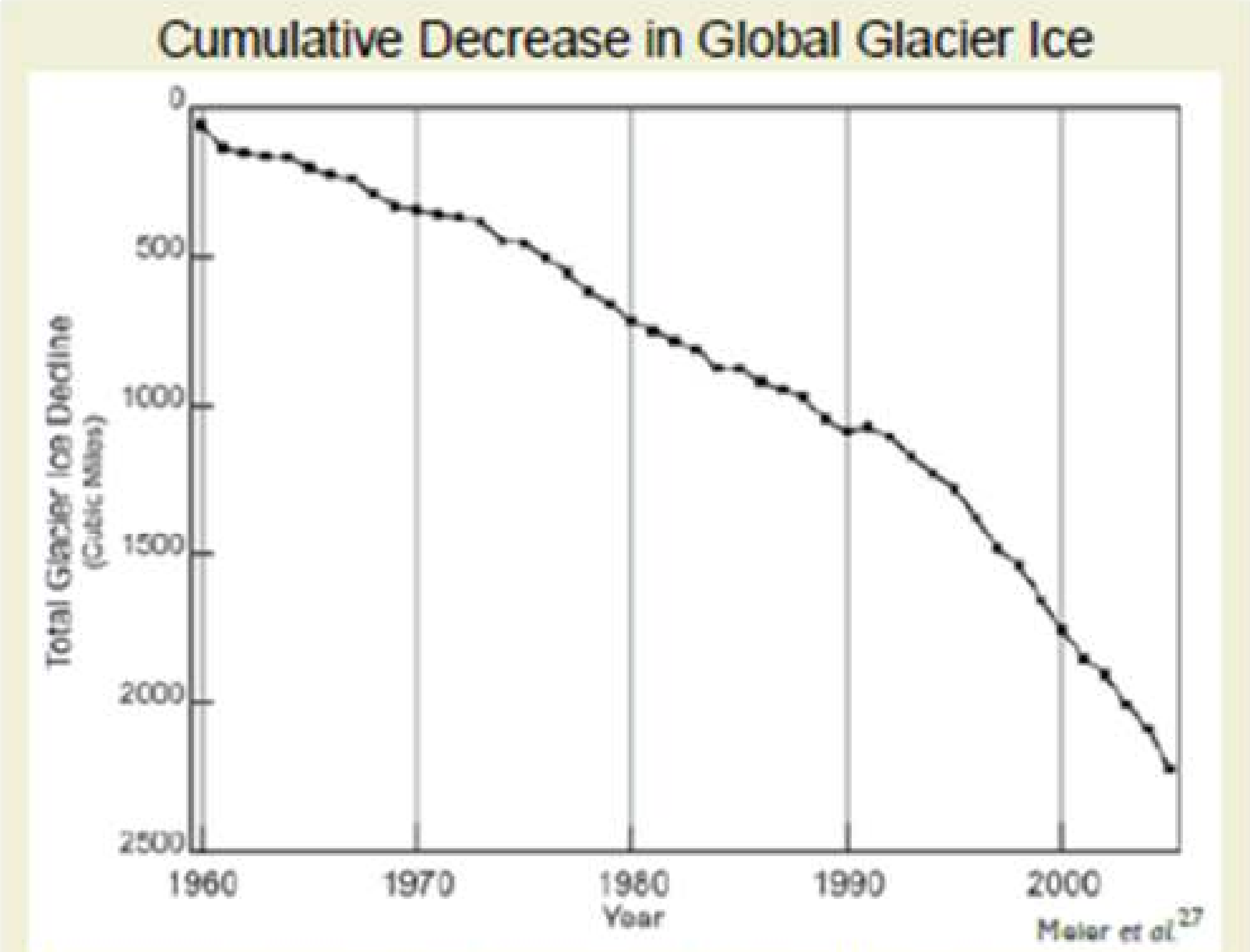


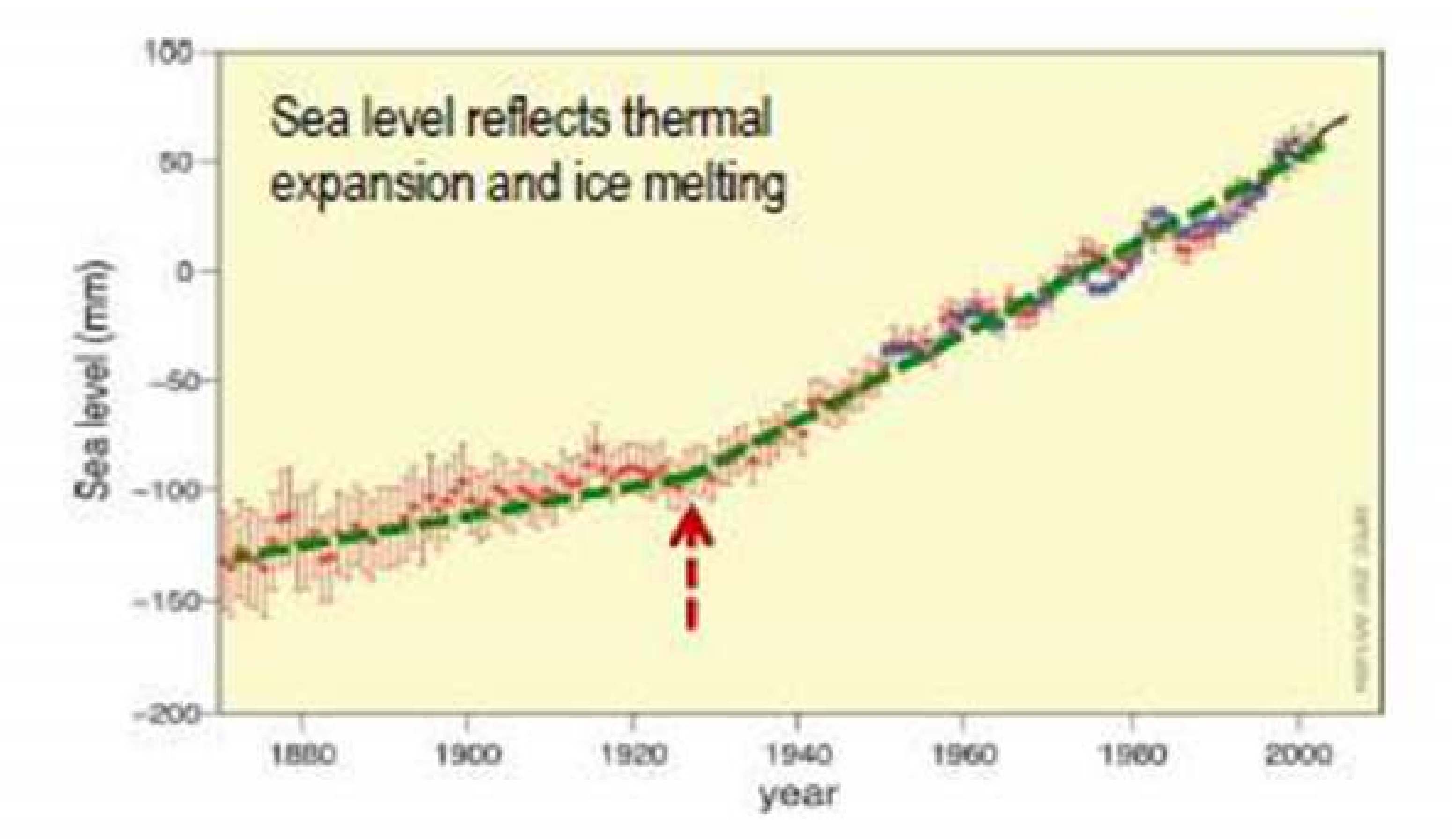
As temperatures have risen, glaciers around the world have shrunk. The graph shows the cumulative decline in glacier ice worldwide.

Global Climate Change Impacts in the United States, Thomas R. Karl, Jerry M. Melillo, and Thomas C. Peterson, (eds.). Cambridge University Press, 2009.

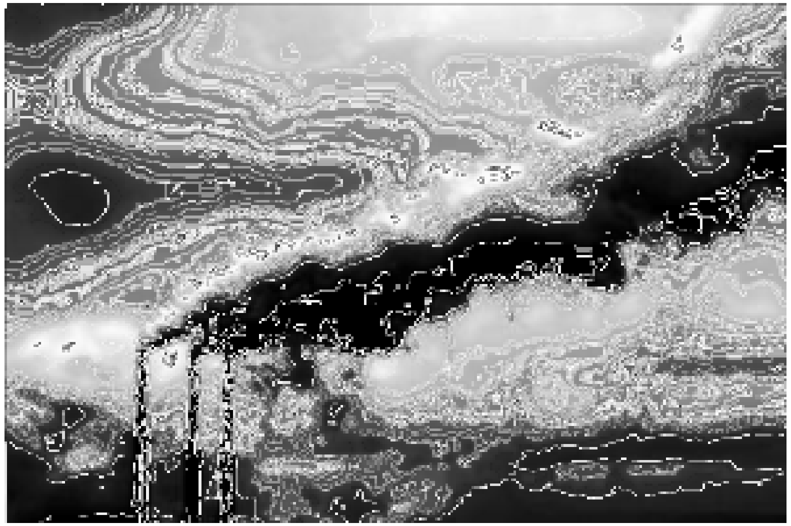
Predicted impacts of global warming

- Sea level rise
- More frequent and severe weather events – storms, droughts, heatwaves
- More frequent and severe fire events
- Spread of tropical diseases
- Earlier onsets of spring & thawing
- Changes in agriculture & ecosystems

ALL of these have been observed and reported in scientific studies



Solomon et al. 2007. Technical Summary In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change



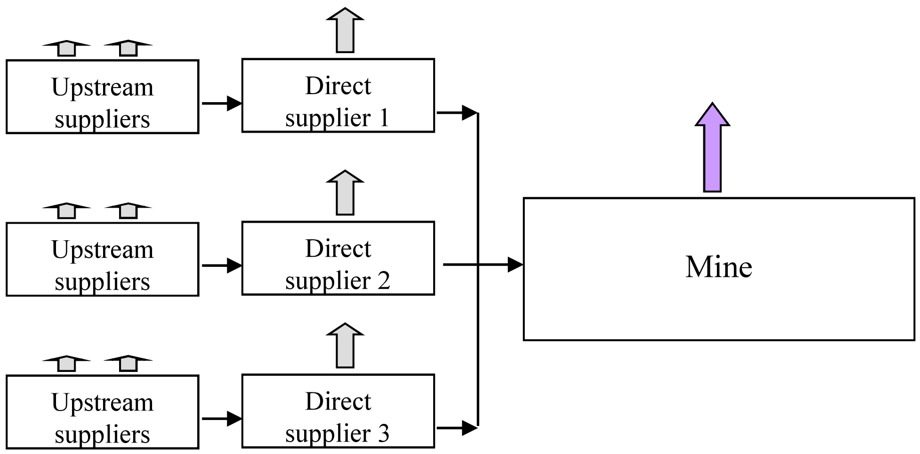
Explosives life cycle and GHG footprint

IPCC guidelines

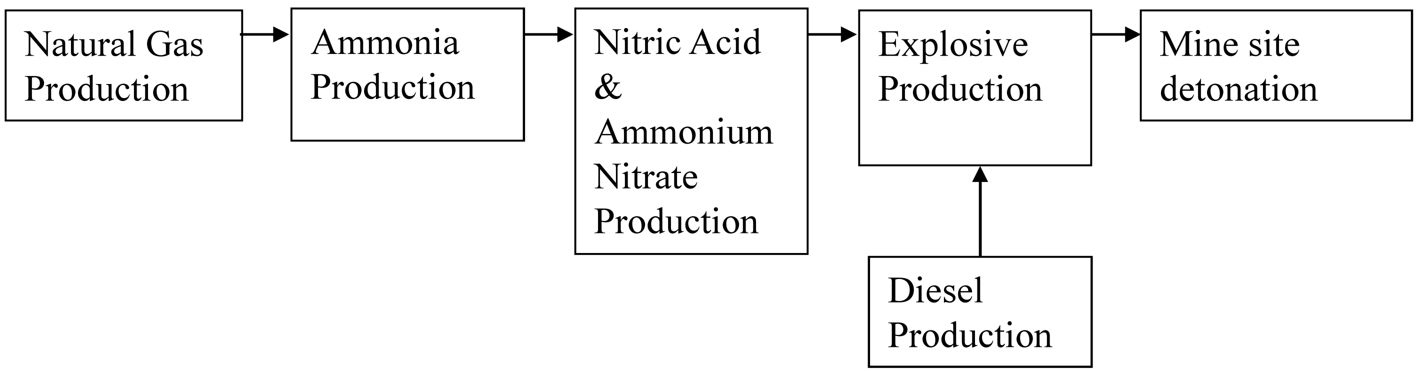
Explosive detonation not currently in IPCC guidelines….

Life cycle approach

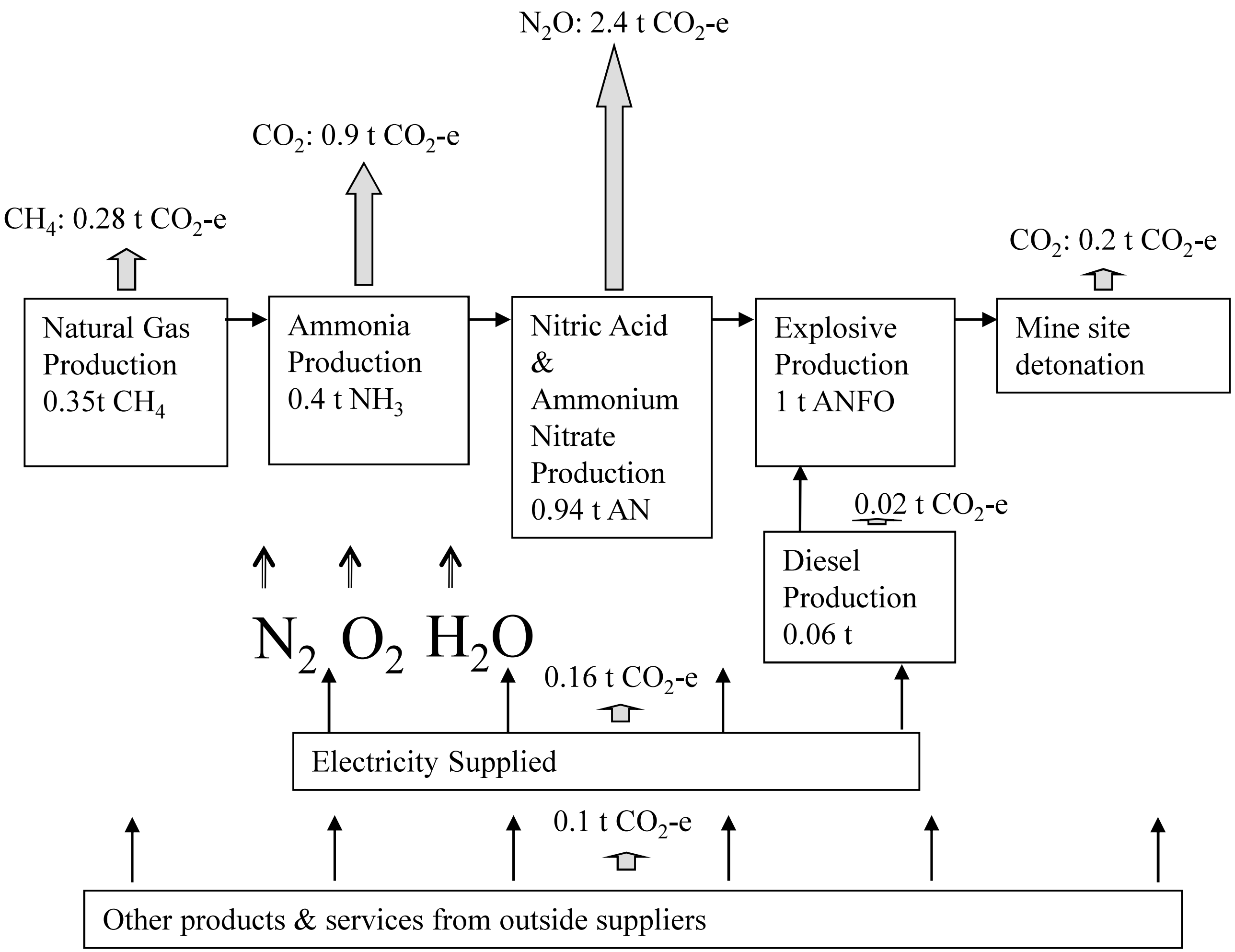
- Understand all embodied energy & emissions in production chain
- Ensure impacts are not increased at other points in the chain (eg increased emissions upstream or from substitution of energy forms)



Explosives life cycle



Explosives life cycle - GHG emissions



Total ~ 4 t CO_2 /t ANFO

Detonation and GHGs

Virtually impossible to measure….

Problems with detonation codes for GHG

- Ideal thermodynamics only – no kinetics, infinite diameter, perfect confinement, complete reaction, homogeneity, perfect mixing, equilibrium, no water etc
- Not all gas species predicted eg N_2O
- Varies by assumed end-pressure
- Various codes will predict different spectra
- CH_4 can dominate at negative OB
  (but it is likely to combust in atmosphere)

Ideal code spectra – *what end pressure ?*

Gas Species	Detonation State 4.9 GPa (% m/m)	Expansion to 100 MPa (% m/m)	Expansion to 100 kPa (% m/m)
H_2O	48.7	48.3	48.6
N_2	32.8	32.9	32.9
CO_2	**16.9**	**17.9**	**18.2**
CO	1.43	0.77	0.00
CH_4 (as CO_2-e)	**0.00 (0.00)**	**0.00 (0.00)**	**0.33 (6.93)**
H_2	0.054	0.11	0.001
NH_3	0.085	0.004	0.001
O_2	0.005	0.00	0.00
NO	0.067	0.00	0.00
C(solid)	0.00	0.00	0.00

Brent, 2009. Greenhouse gas implications of explosives and blasting, *Proc. 9th Int. Symposium on Rock Fragmentation by Blasting, Fragblast-9 673-682*, CRC Press/Balkema, Leiden.

Proposed convention for detonation GHG

- Assume all C completely oxidised to CO_2
  (reasonable to assume CH_4 and CO oxidise)
- Ignore minor species formation
- Total C → Total CO_2

- Exceptions:
- Carbonates – already more thermodynamically stable than CO_2 (eg $CaCO_3$)
- Biofuels - to be treated as per rulings on % C neutral

Advantages of proposed convention

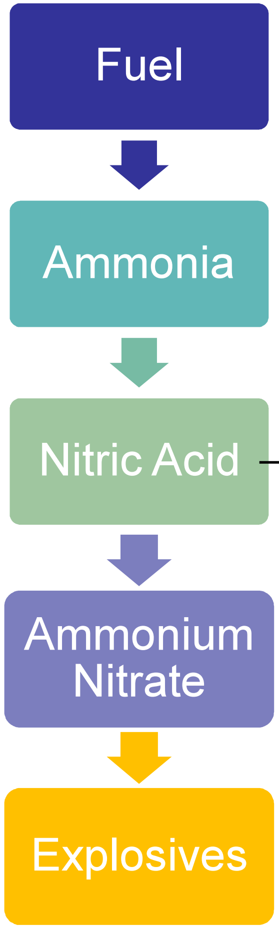
- Consistent results across manufacturers – not code or convention dependent
- Transparent, auditable- based on C content
- Takes account of all C to CO_2 but does not introduce spurious results from (GHG dominant) minor species
- Defensible technical basis
- No expensive *(questionable)* measurements

Reducing the GHGs in explosives

Targets for reductions

- N_2O abatement in Nitric Acid manufacture
- CO_2 reductions in ammonia manufacture - difficult: -renewable energy/feedstocks ?
  -carbon capture and storage ?
- CO_2 reductions in explosives fuel
  - biofuels already used where possible

Nitric Acid and Ammonium Nitrate Production



Ammonia + Air + Water → Nitric Acid + Waste Gas

$$NH_3 + O_2 + N_2 + H_2O \rightarrow HNO_3 + N_2 + O_2 + H_2O + NO_x + N_2O$$

First step:

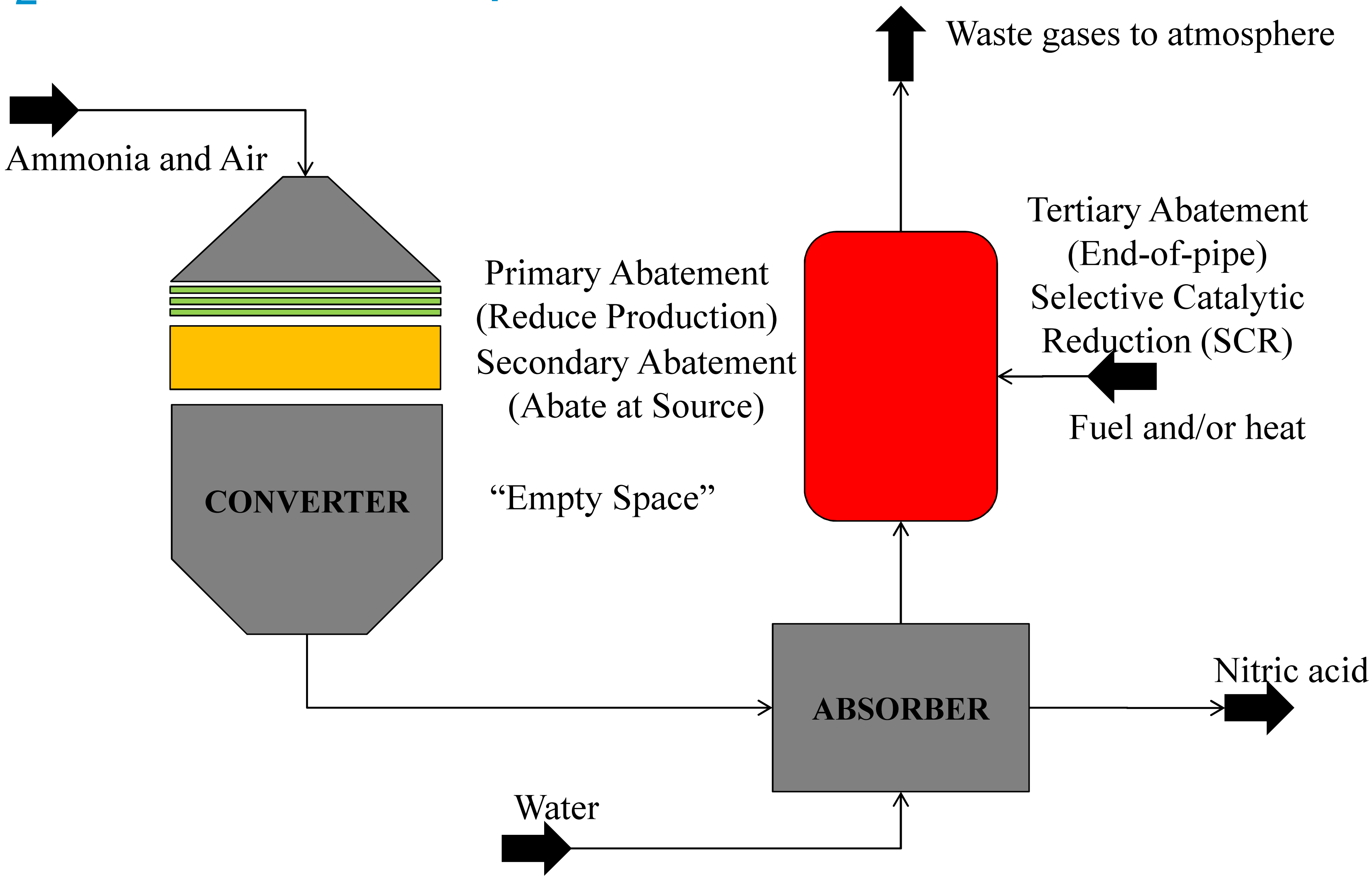
$$NH_3 + O_2 \rightarrow H_2O + NO + N_2 + N_2O$$

310 t CO_2e per t N_2O

N_2O formation depends on pressure, temperature, and gas velocity

Low (●), Medium (●), and High (●) Pressure Plants

N_2O Abatement Options



Actions and Plans

Actions

- Carseland, Canada (2008) reduced emissions by > 345,000 t $CO_{2\text{-eq}}$/a
- Bacong, Philippines (2009) reduced emissions by > 25,000 t $CO_{2\text{-eq}}$/a
- Yarwun, Australia (2010) reduced emissions by > 300,000 t $CO_{2\text{-eq}}$/a

All using Secondary Abatement

Future Plans

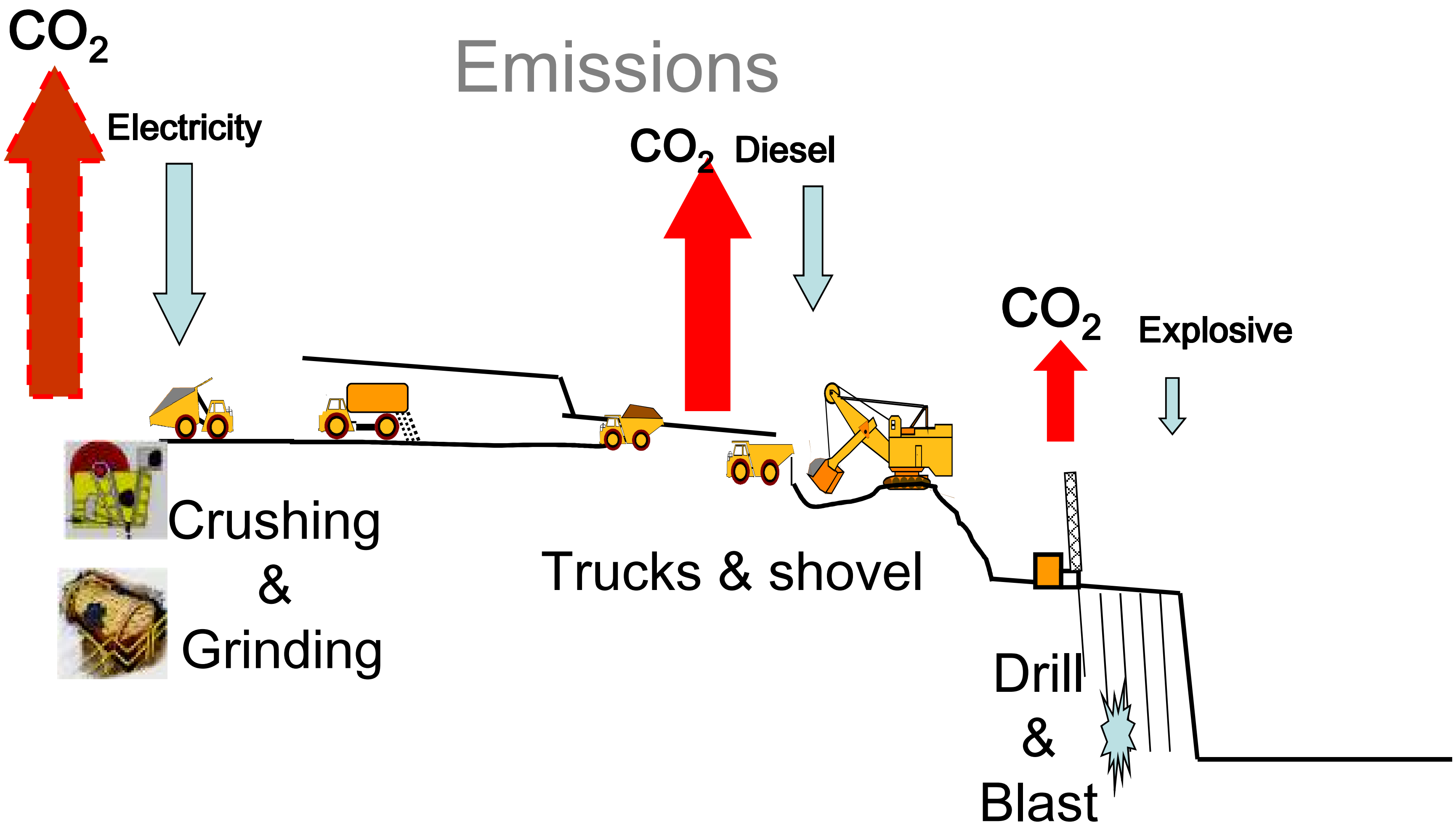
- Abatement for our 4 high pressure Weatherly plants in Australia

In Sustainability, N_2O Abatement is Orica's Priority Action No. 1

ORICA MINING SERVICES

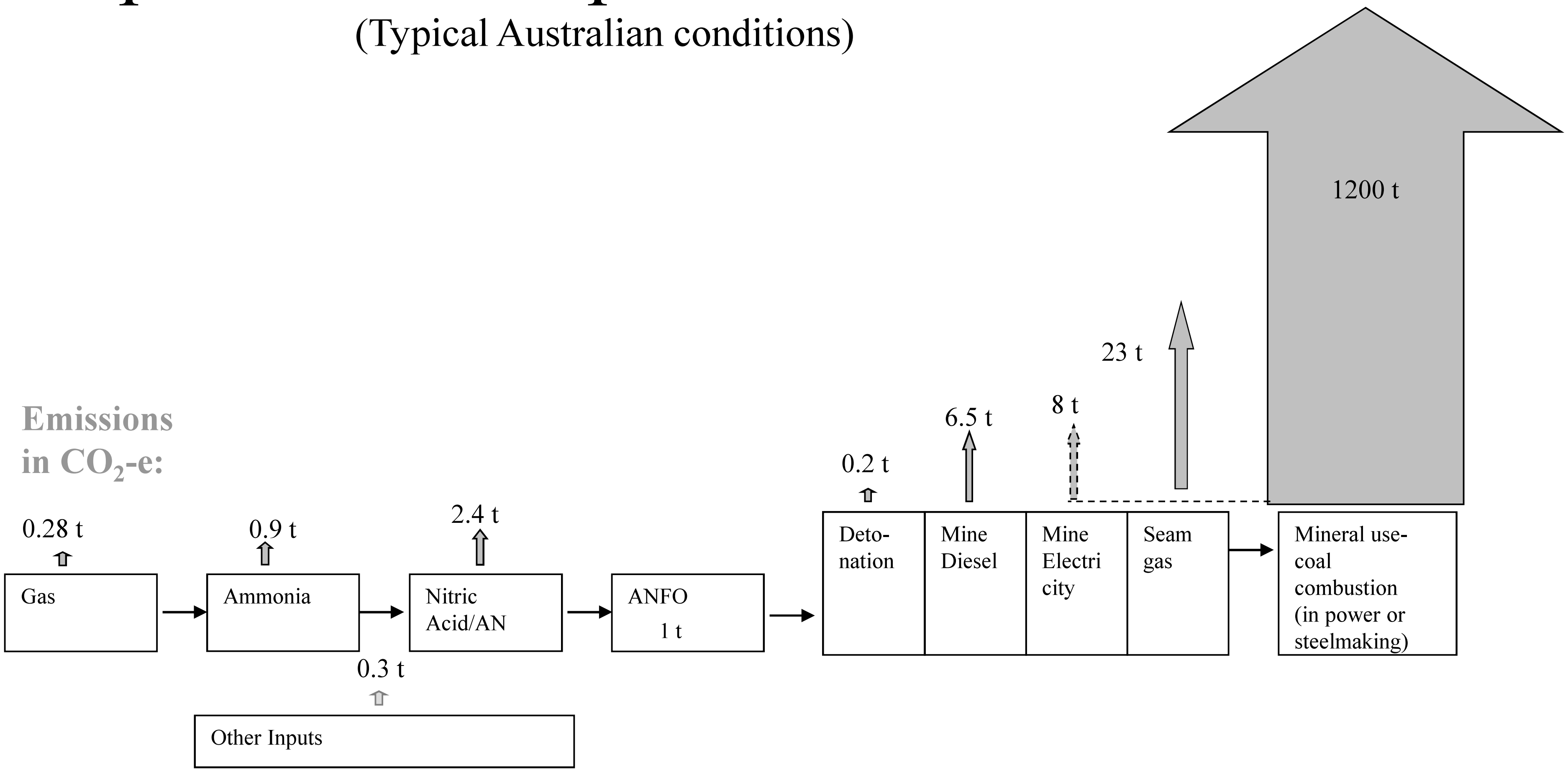
Downstream mining & mineral impacts

Metalliferous Mine



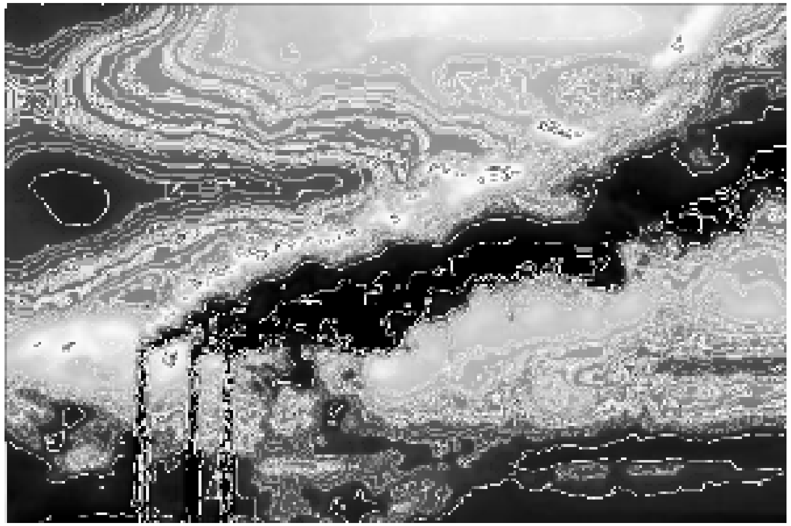
Explosives into open cut coal mines

(Typical Australian conditions)



1 t EXPLOSIVE
Total emissions ~ 4 t CO_2-e

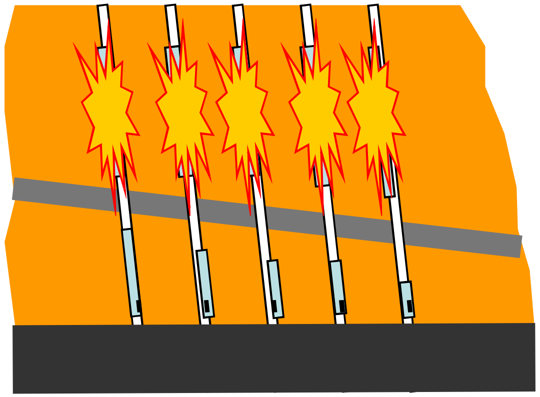
500 t COAL mined
Total emissions ~ 1230 t CO_2-e

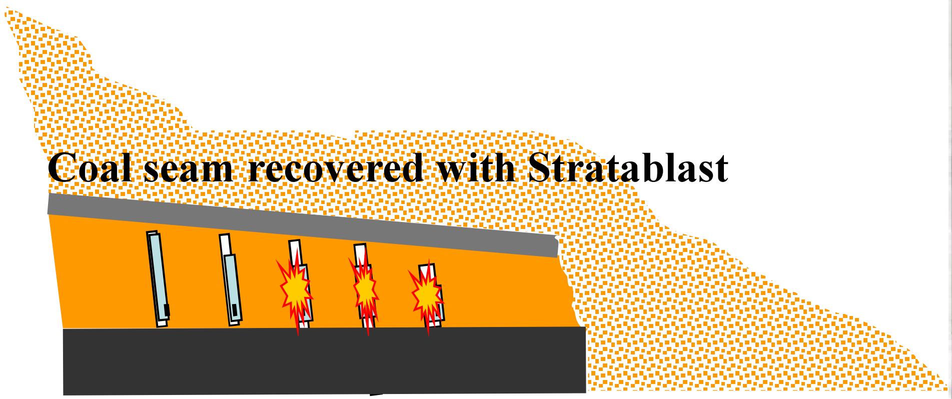


How blasting can make a difference

Throw blasting improved with electronic detonators

Coal loss eliminated with Stratablast^{TM}





Improved fragmentation to reduce grinding electricity consumption

How blasting can make a difference

Blast Scenario	Blasting Impact	Reduction in mine GHG intensity
Throw Blasting (electronics)	5-7 % reduction in overburden volumes	1-2 %
Improved Fragmentation (20 % more explosives)	10 % increase in mill throughput	6 %
Coal Recovery (Stratablast)	5-25 % increase in coal recovery	5- 25 %

Latest Orica R&D is focussing on increasing explosive energy to make larger reductions in mine emissions and strategic research on C capture and storage

Thank you……

Contact: geoff.brent@orica.com