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# Climate: A whirlwind tour

Open Seminar Series, Department of Physics

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# Climate change

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Regional warming in the decade 2006-2015 relative to preindustrial

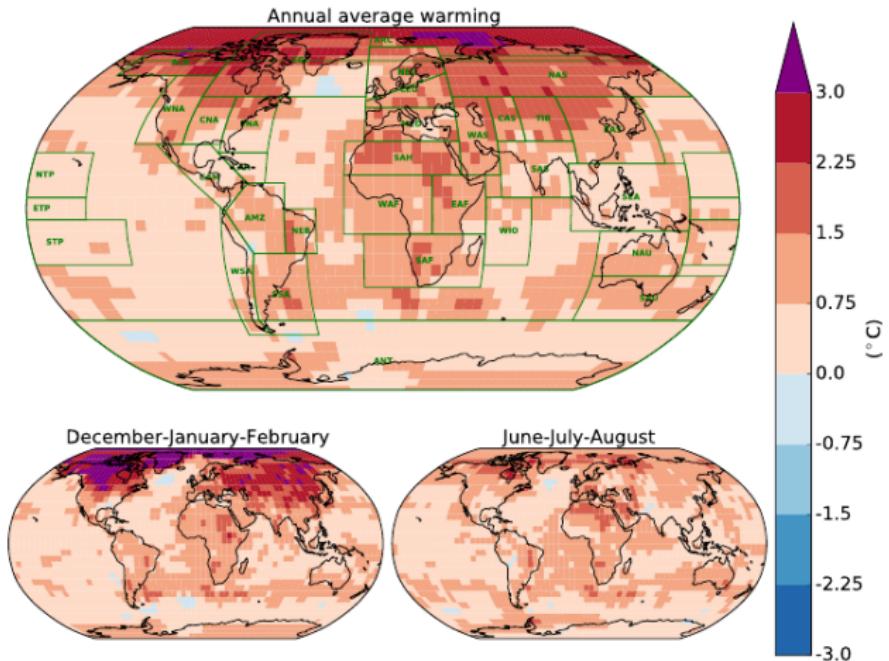


Figure 1 : Temperature change (2005 - 2015) with respect to  
pre-industrial (1850-1900). Source: *IPCC SR15, 2018*.

# Historical CO<sub>2</sub> levels

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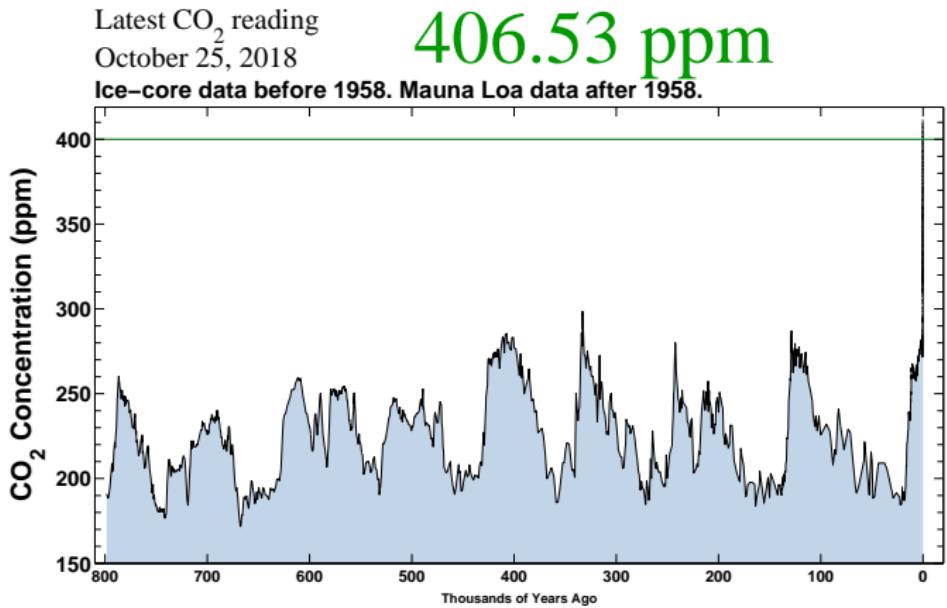


Figure 2 : Historical CO<sub>2</sub> levels. Source: *Scripps, UCSD*

# Palaeo record

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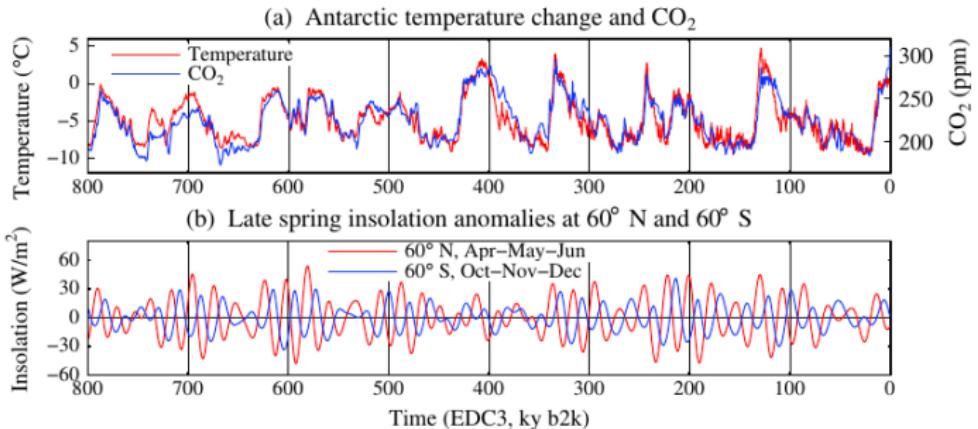


Figure 3 : (a) Antarctic (Dome C) temperature anomaly relative to 10ky, CO<sub>2</sub> levels (Lüthi et al., 2008); (b) Insolation anomalies.

Source: (Hansen et al., 2016)

# Radiative forcing

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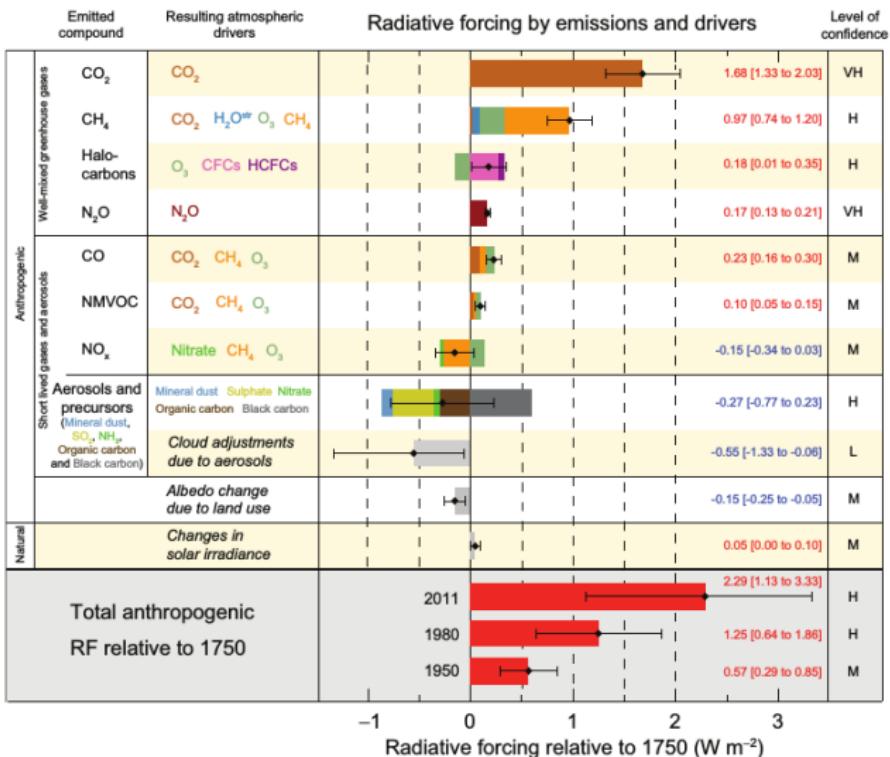
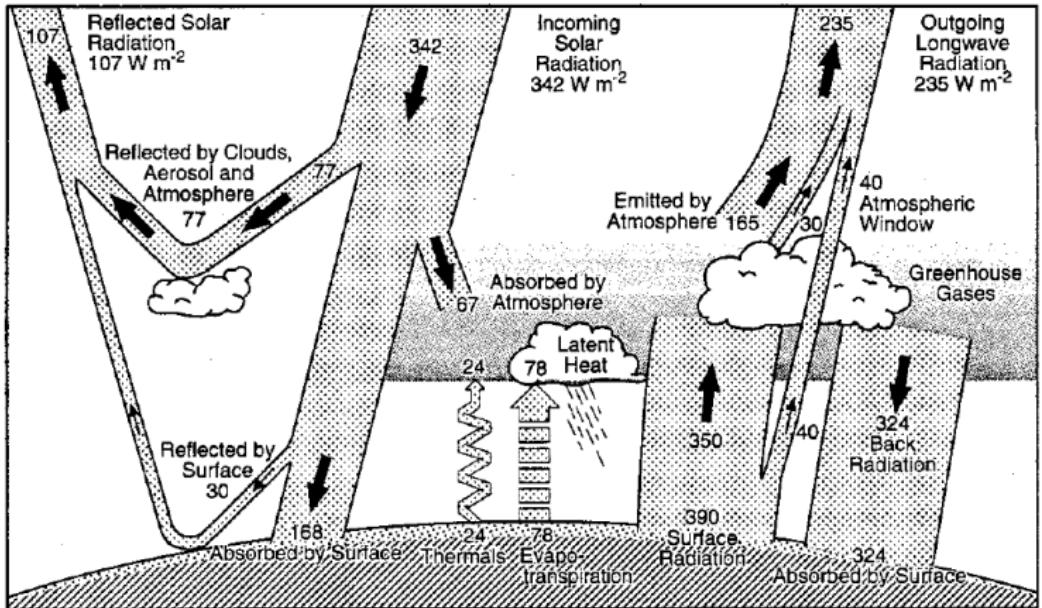


Figure 4 : Radiative forcing. Source: IPCC-WG1, 2013

# Earth's energy budget

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**Figure 5 :** (Kiehl and Trenberth, 1997)

# Aerosols

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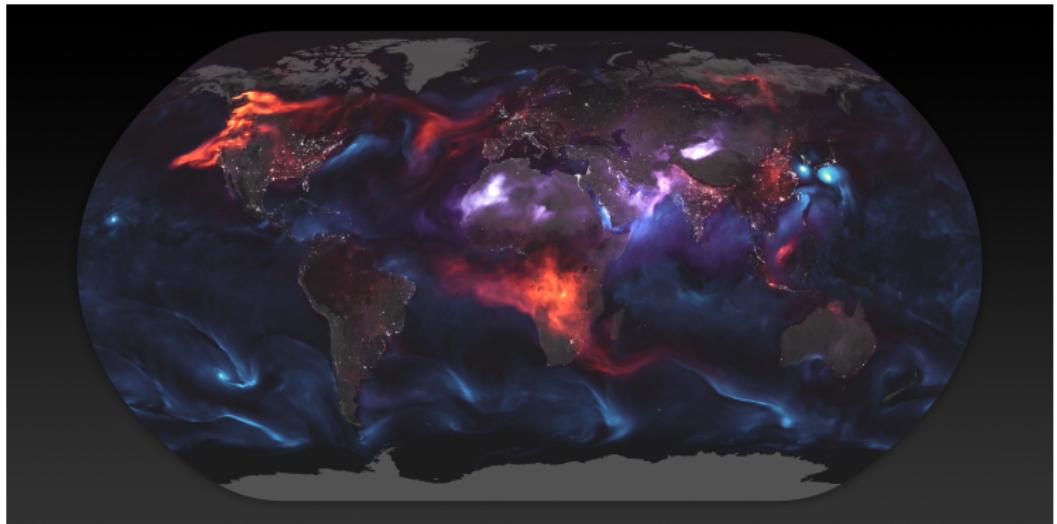


Figure 6 : Wildfires, dust, and sea salt - August 23rd, 2018. Source:

NASA GEOS-FP

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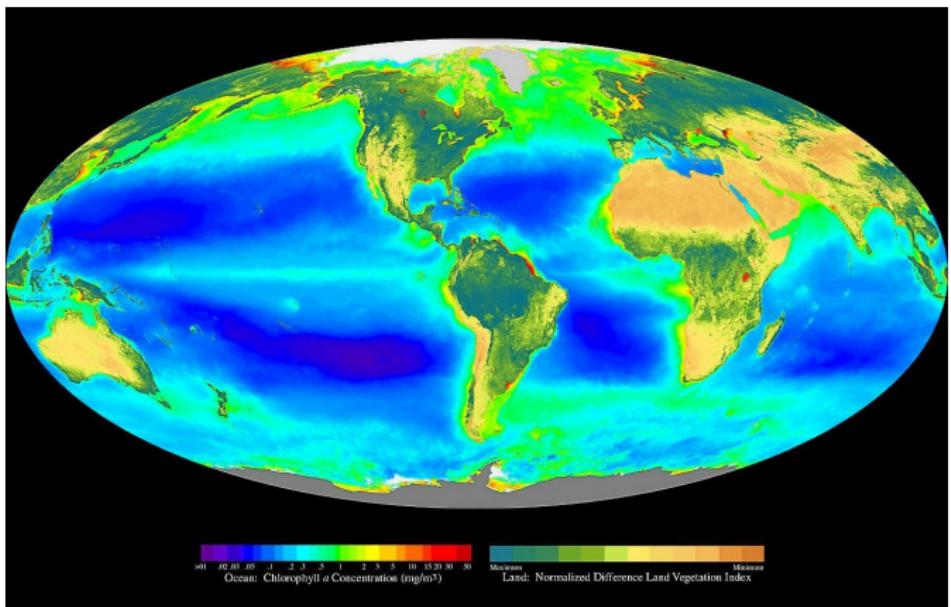
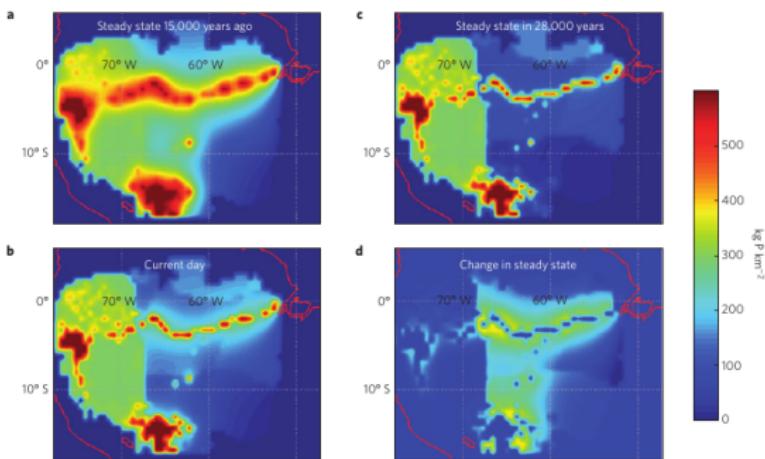


Figure 7 : Abundance of photosynthesizing organisms. Source: NASA,  
GSFC (SeaWiFS)



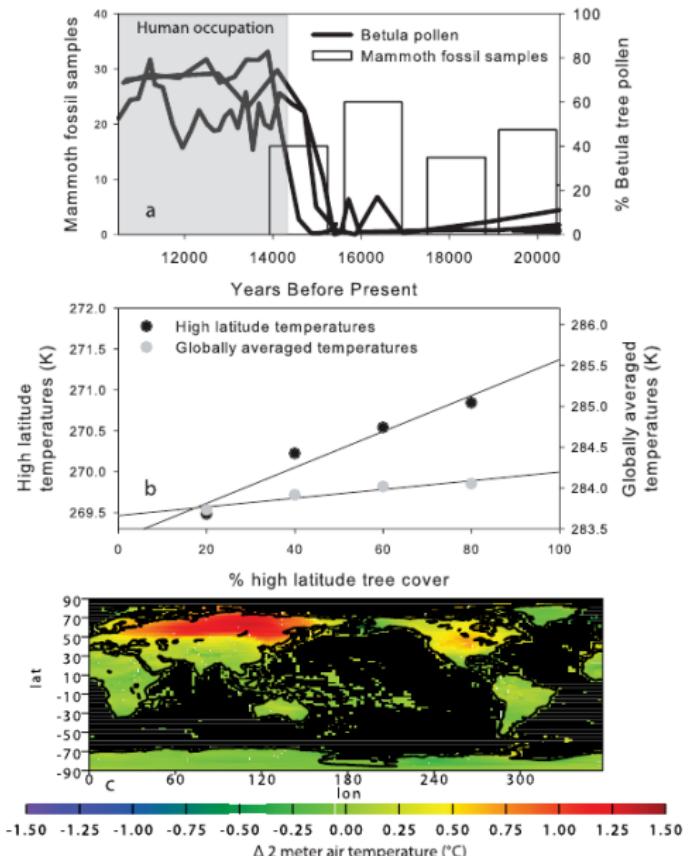
**Figure 3 | Map showing changing ecosystem P concentrations in South America due to megafauna extinctions.** **a**, The steady-state estimate of P concentrations in the Amazon basin before the megafaunal extinctions with a lateral diffusivity  $\Phi_{\text{excreta}}$  value of  $4.4 \text{ km}^2 \text{ yr}^{-1}$ . **b**, The current-day estimate of P concentrations 12,000 years after the extinctions with current animals and a  $\Phi_{\text{excreta}}$  value of  $0.027 \text{ km}^2 \text{ yr}^{-1}$ . **c**, Estimated P concentrations in the Amazon basin 28,000 years in the future. **d**, The difference between the pre- and post-extinction equilibrium (**a** and **c**).

**Table 1 | Average  $\Phi_{\text{excreta}} * \alpha B (\text{km}^2 \text{ yr}^{-1})$  for each continent calculated for modern species and modern plus extinct species.**

	North America	South America	Australia	Eurasia	Africa
Number of species extinct	65	64	45	9	13
Mean weight of extinct animals (kg)	846	1,156	188	2,430	970
Modern $\Phi_{\text{excreta}} * \alpha B$	13,876	12,934	21,804	21,779	265,621
Modern + extinct fauna $\Phi_{\text{excreta}} * \alpha B$	140,716 ( $\pm 38,000$ )	283,854 ( $\pm 81,000$ )	48,250 ( $\pm 8,000$ )	118,349 ( $\pm 29,000$ )	324,848 ( $\pm 18,000$ )
Percentage of original	10% ( $\pm 2\%$ )	5% ( $\pm 1\%$ )	45% ( $\pm 6\%$ )	18% ( $\pm 4\%$ )	82% ( $\pm 4\%$ )

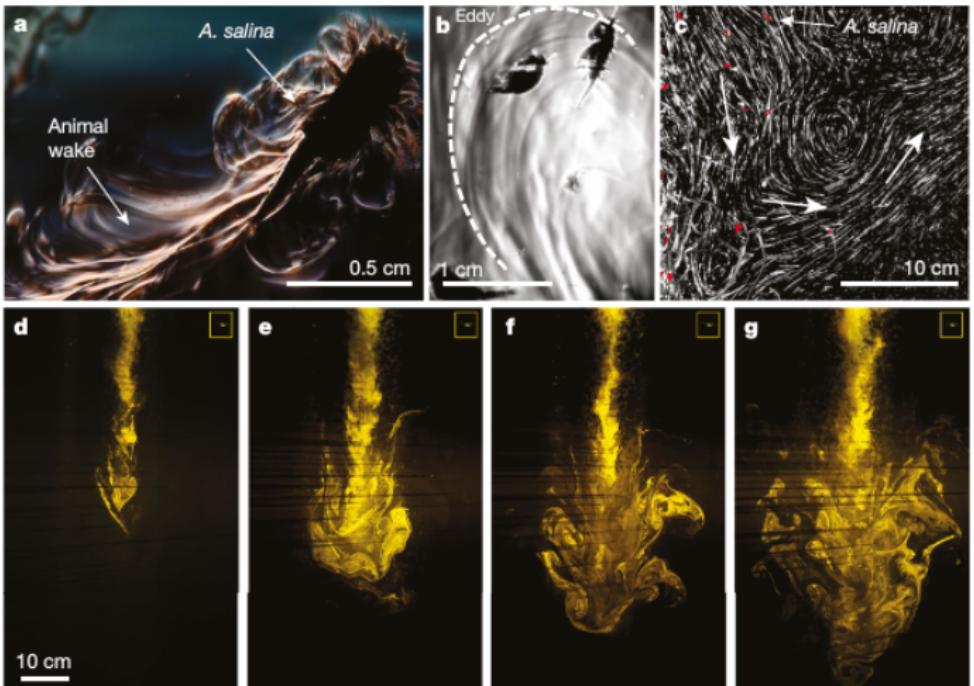
Bottom row is the percentage of the original  $\Phi_{\text{excreta}} * \alpha B$  remaining. The error represents an uncertainty in extinct species distribution of 30%.

## Biosphere



**Figure 9 :** Source: (Doughty et al., 2010)

## Biosphere



**Figure 10 :** Flow visualization of diffusion caused by the vertical migration of *A. Salina* (brine shrimp).  $\nu_{\text{eff}}/\nu_{\text{mol}} \approx 10^3$  Source: (Houghton et al., 2018)

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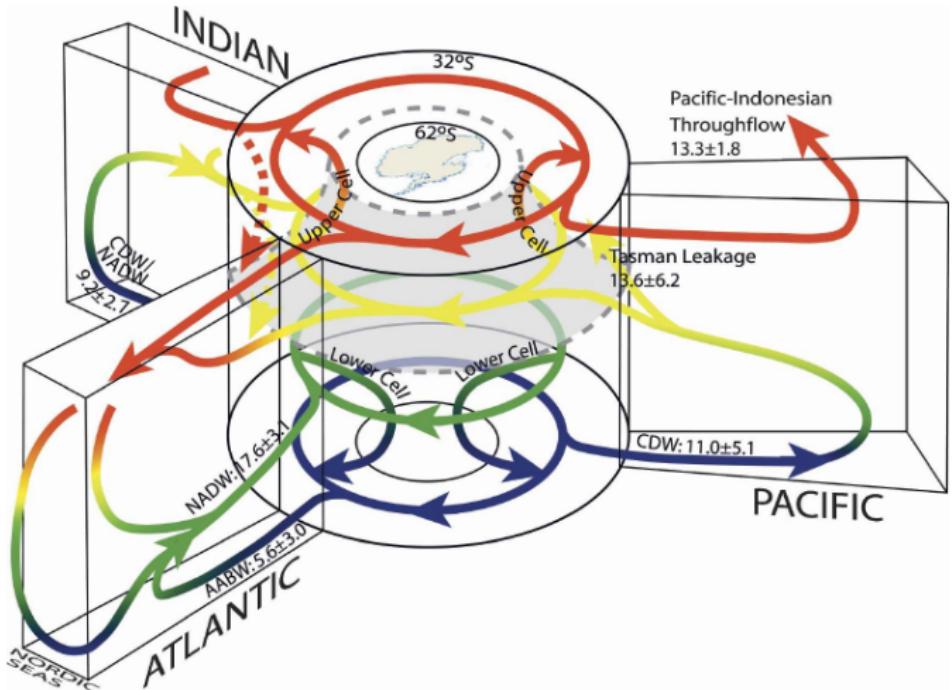


Figure 11 : Global thermohaline circulation source: Lumpkin and Speer, 2007  
(Lumpkin and Speer, 2007)

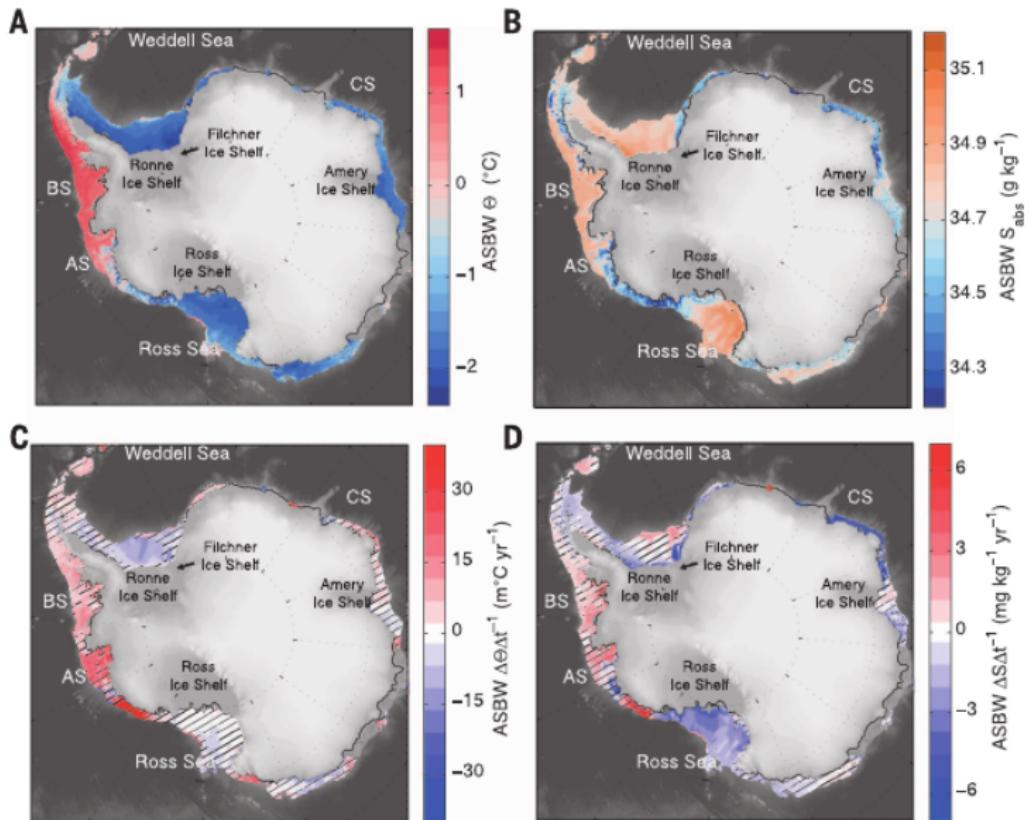
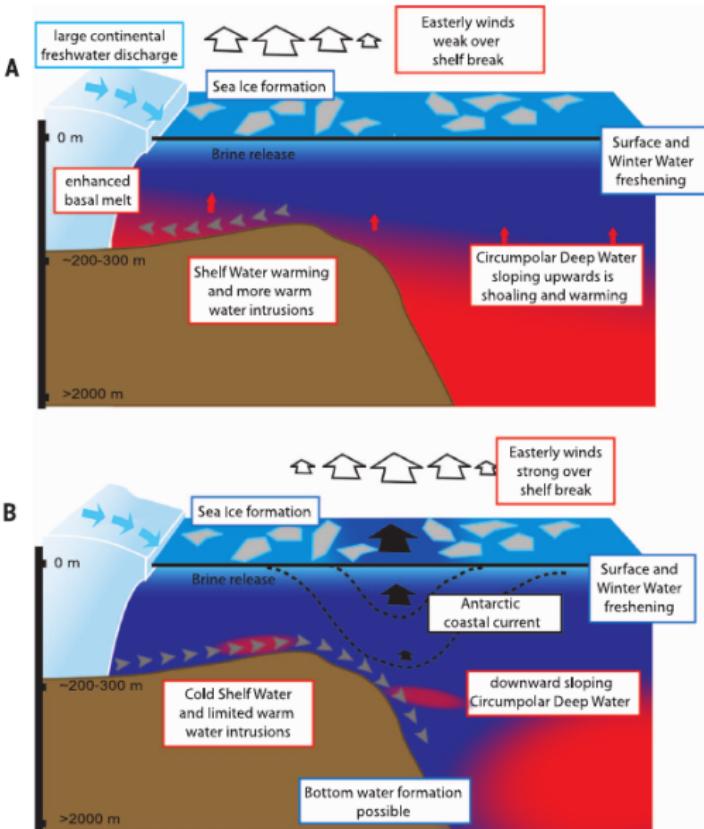


Figure 12 : Antarctic shelf sea bottom water properties and trends. Source: (Schmidtko et al., 2014)



**Figure 13 :** Mechanisms of ocean currents warming the continental ice shelves of the Antarctic. Source: (Schmidtke et al., 2014)

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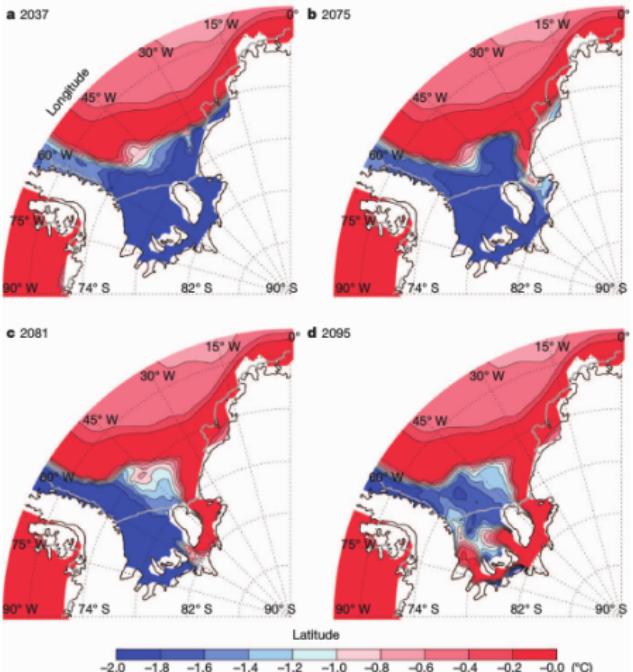


Figure 14 : Modelling the future shelf bed of the Weddell Sea.

Source: (Hellmer et al., 2012)

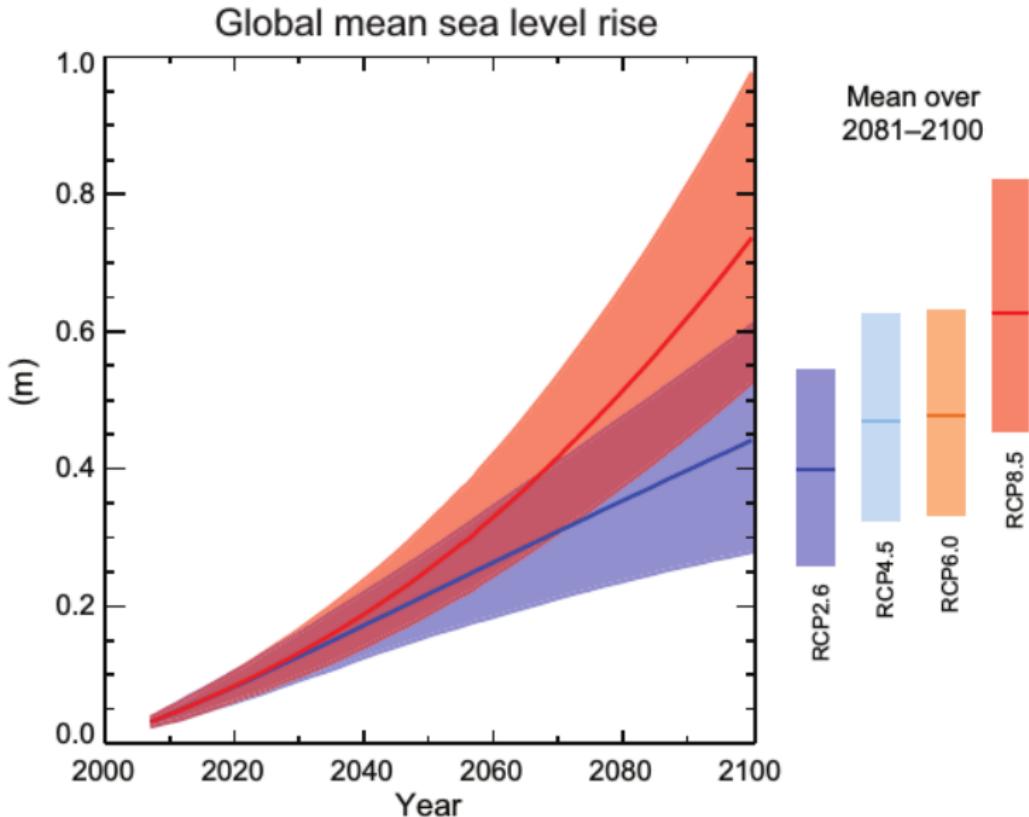


Figure 15 : IPCC 2013, sea level rise projections. Source: IPCC 2013,

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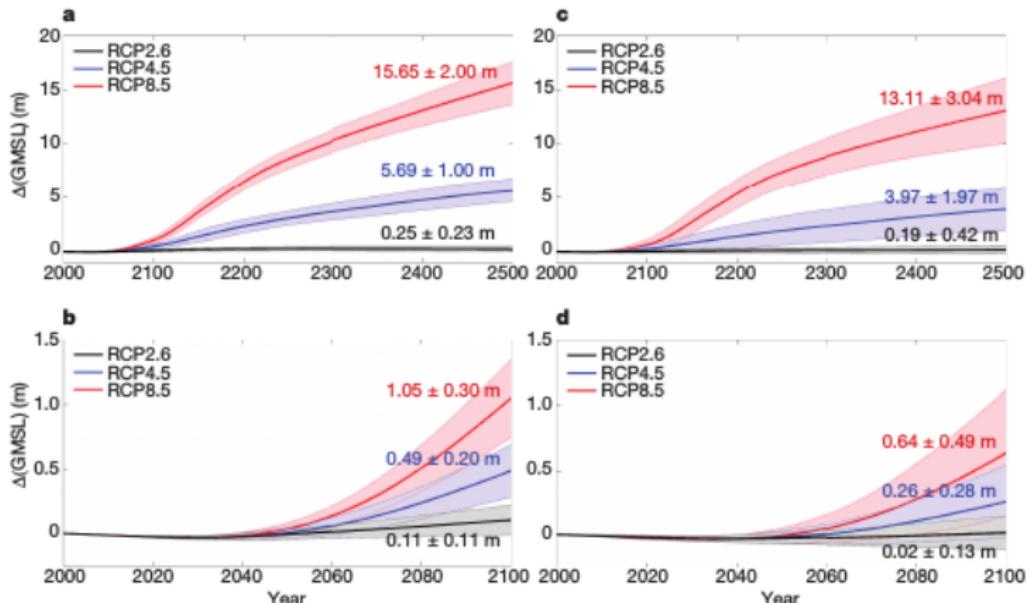


Figure 16 : Model analyses of future Antarctic contribution to sea level rise. Source: (DeConto and Pollard, 2016)

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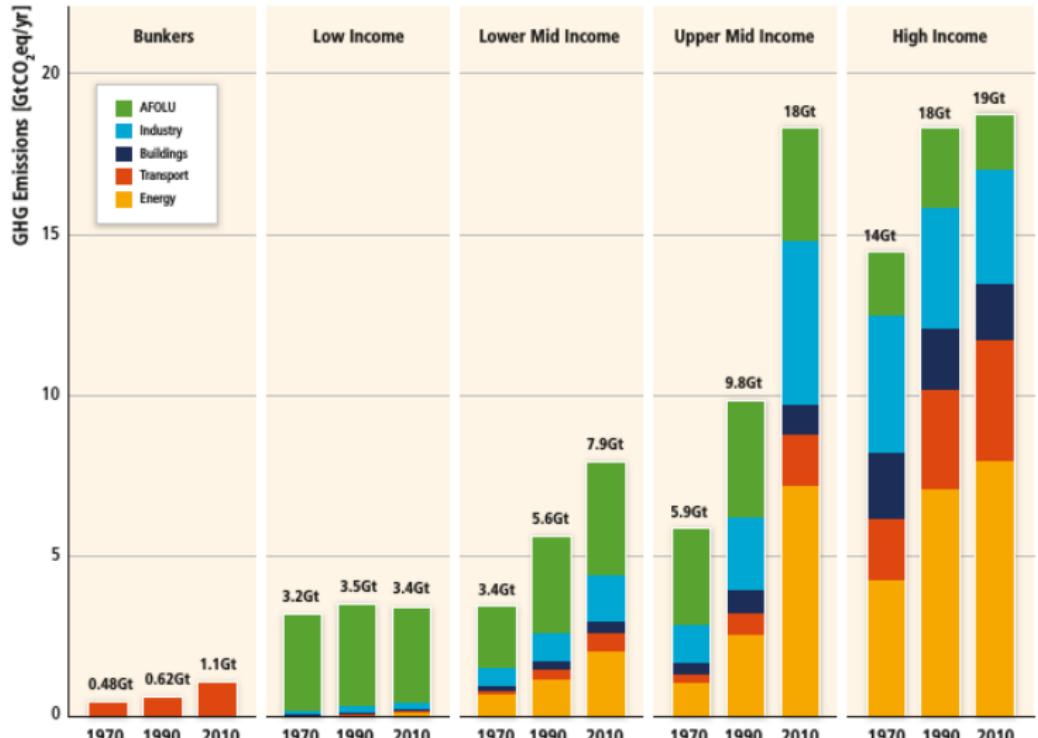


Figure 17 : Source: Fig. TS3, IPCC, 2013, WG-3

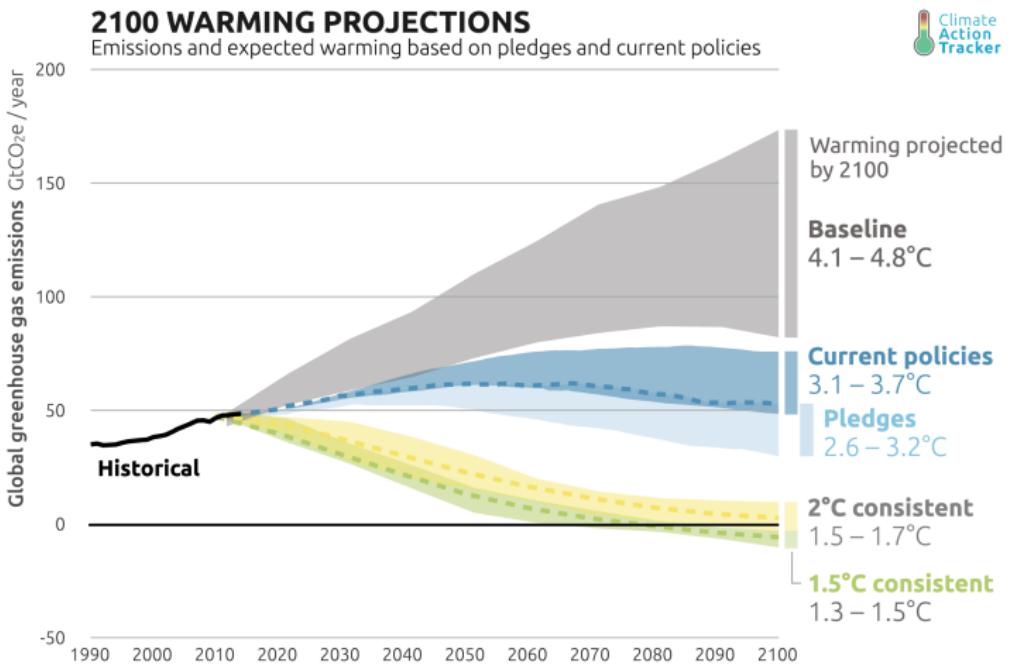


Figure 18 : Source: Climate Action Tracker

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