capture & sequestration techniques, for instance). In consequence, disparities get reduced rather than increased. Social stretching and potential rupture is not only avoided but reversed, and world society is closing ranks within a safe operating space (Rockström *et al.*, 2009).

Let us end by emphasizing that great transformational changes lie ahead of us in either case – whether we choose to pursue "business as usual" as long as possible or to adopt "sustainable development" as soon as necessary. "Don't think that nothing happens, if nothing happens!", as the German Chancellor Angela Merkel put it recently (paraphrased from the WBGU-Symposium 2012). Humankind is currently distorting the fabric of the climate system without fully understanding its making, thereby risking to sever critical links and to cause major discontinuities and disruptions. Research, science and education will play a decisive role in making the right choice, not least by providing robust evidence about the risks *and* the opportunities involved. In particular, the knowledge enterprise can outline powerful solutions and strategies for reconciling nature and humanity. This will require, however, to also transform our thinking about the world: "Problems cannot be solved with the same mindset that created them" (Albert Einstein).

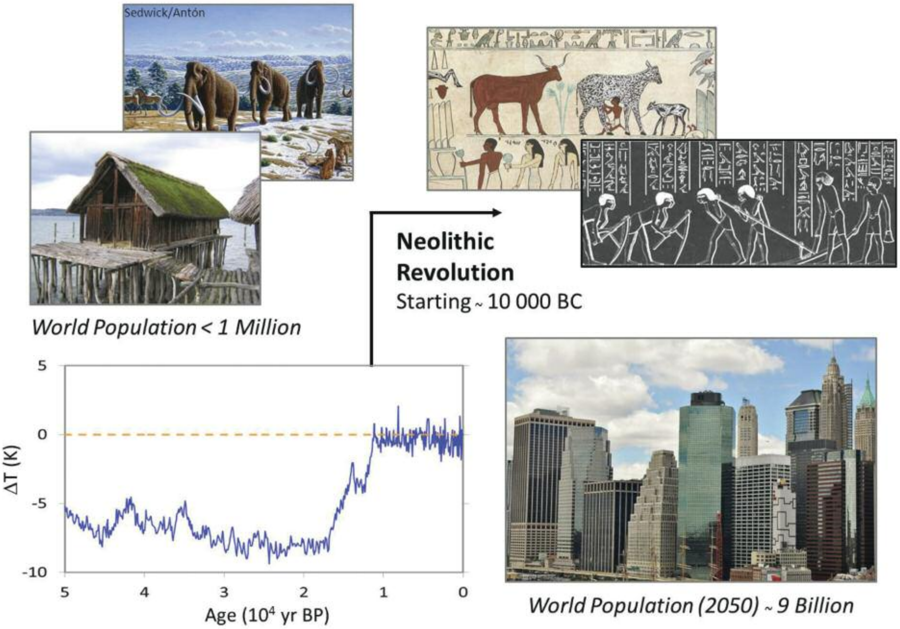

Figure 1: The Neolithic Revolution in the Holocene. With the onset of the stable climate of the Holocene some 12 000 years ago, small groups of human hunters and gatherers wandering the continents were given the opportunity to settle down. They practiced agriculture and domestication of plants and animals, but also transformed their societies into a more efficient system based on division of labor and trading. This change in life style allowed for the world population to eventually surpass the small number of less than a million individuals. The next major transformation was to ignite in the mid-18th century in Britain (Figure 2).

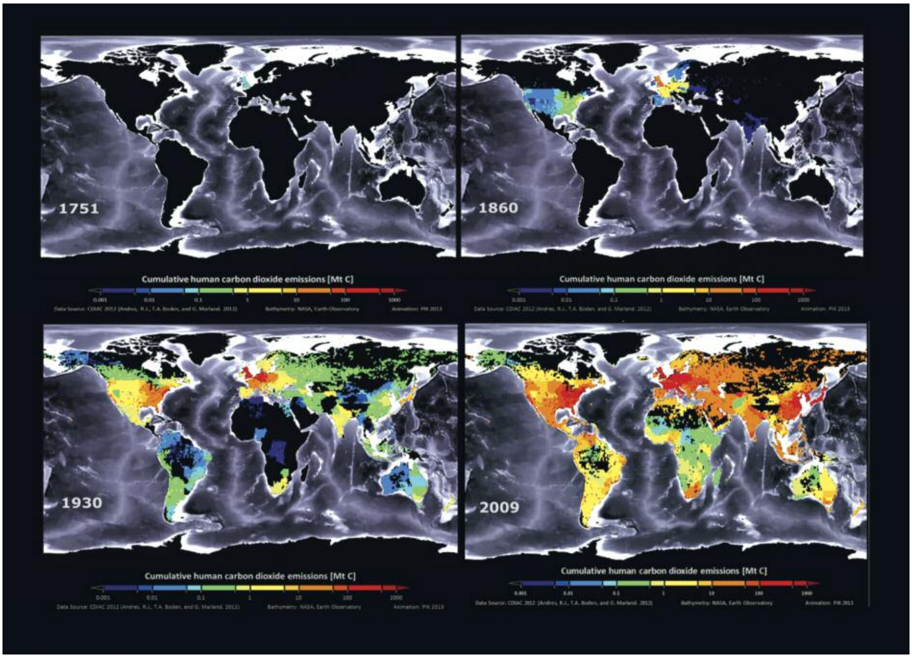

Figure 2: The “C-Story of Humankind”: Cumulative Human Carbon Dioxide Emissions since the Industrial Revolution. Income, population density and cumulative emissions of carbon dioxide have undergone a remarkably parallel development since the industrial revolution, which originated in the textile industry of Lancashire, England, around 1760 and initiated the use of coal for manufacturing processes. The transformation of first the production and subsequently the transportation sector to a carbon-based economy initially spread to Western Europe and the United States. Later, around the beginning of the 20^{th} century, the cumulative emissions of Co_2 become also significant for the overseas colonies and China. The current situation reflects the foundation of modern living on fossil carbon around the globe. For an animated version please refer to the web link in the bibliography (PIK 2013).

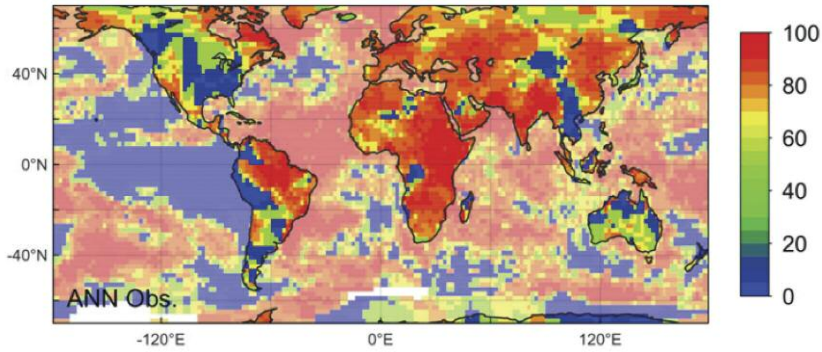

Figure 3: Heat Records due to Climate Change. Record-breaking monthly mean temperatures occur more often than could be expected from natural variability. The probability that such events in the last decade are due to climate change is about 80% in the global average (Coumou *et al.*, 2013).

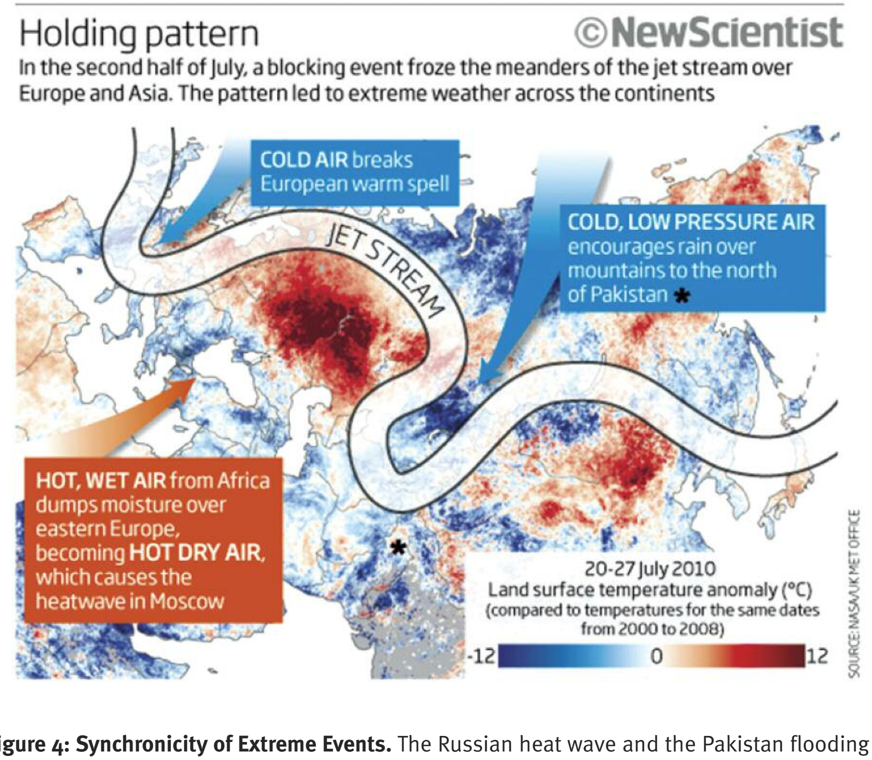

Figure 4: Synchronicity of Extreme Events. The Russian heat wave and the Pakistan flooding in 2010 are examples of synchronous extreme events that are tied to a blocking event in the atmosphere: the path of the jet stream freezes and high and low pressure systems stabilize resulting in constant local weather conditions for several weeks.

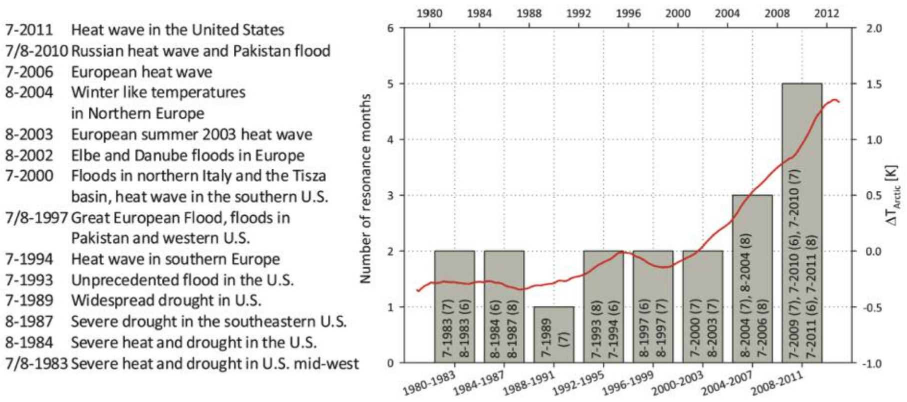

Figure 5: Increase in Quasi-Resonance Events. The increasing difference of surface warming between the Arctic and in the rest of the Northern Hemisphere (red line) as well as the number of July and August resonance months (grey bars, Petoukhov *et al.*, 2013) are associated with extreme weather events (Coumou *et al.*, 2014).

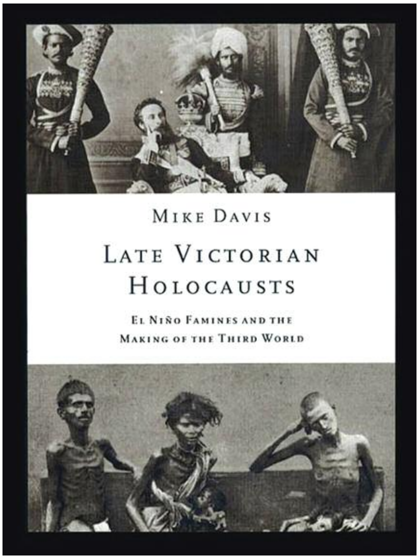

Figure 6: Worldwide Historical Consequences of ENSO Events. In the late 19th century, around 30-50 million premature deaths in India, China and Brazil were related to droughts and monsoon failures, floods and epidemic diseases. Historian Mike Davis attributes the resulting "climates of hunger" to the El Niño-Southern Oscillation (Davis 2002).

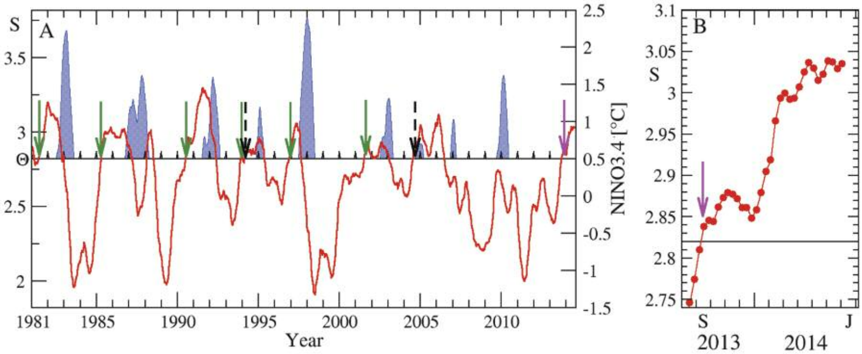

Figure 7: A Novel Method of Forecasting El Niño Events. The link strength *S* , describing teleconnections of temperatures between the El Niño basin and the rest of the Pacific (red curve), can be used as a very early warning bell for El Niño events (blue shaded areas) ringing at least one year ahead: If the link strength crosses a certain threshold from below (arrows) it is followed by an El Niño in three out of four cases (Ludescher *et al.*, 2013, 2014).

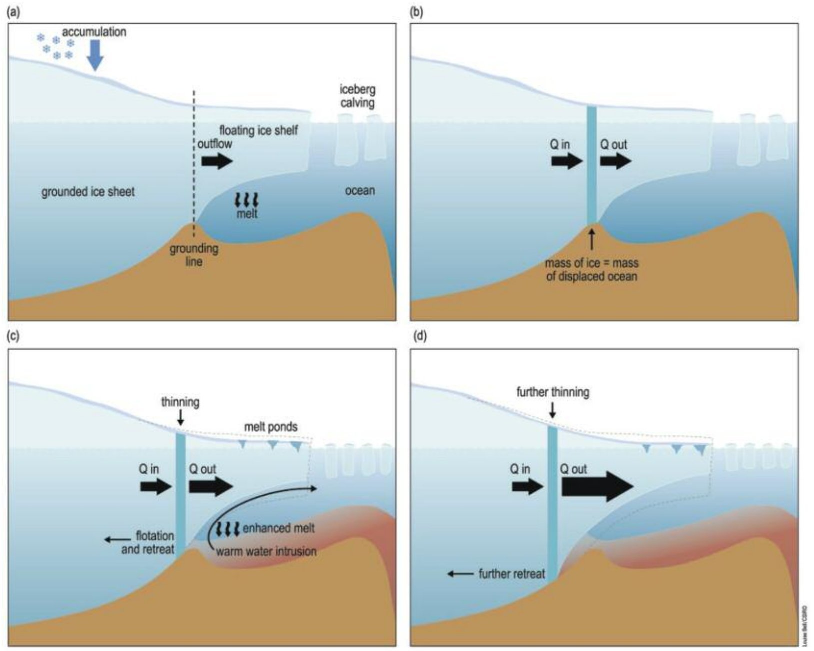

Figure 8: The Marine Ice Sheet Instability. The Marine Ice Sheet Instability (MISI) is the process leading to a potentially unstable retreat of a grounding line. (a) Profile of a marine ice sheet (b) Ice flux at the grounding line in steady state (c) Stronger outflow is triggered by ice-shelf melting and the grounding line starts to retreat. (d) Self-sustained retreat of the grounding line (IPCC WGI, box 13.2, Figure 1, 2013).

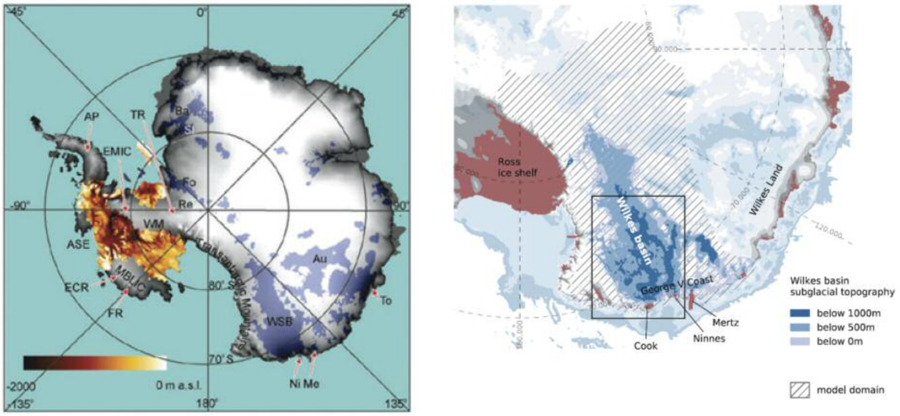

Figure 9: The Tipping Potential of the Antarctic Ice Sheet. Marine regions of the Antarctic ice sheet (i.e., areas where the ice sheet rests on a base below sea level, compare Figure 8) are potentially unstable. Left Panel: The marine West Antarctic ice sheet (red and orange colors) holds enough ice to raise sea level by 3.3 meters (Bamber *et al.*, 2009). The Wilkes Basin in East Antarctic could be subject to self-sustained ice loss as well if a critical ice plug near the cost is removed which would lead to additional 3-4 meters of global sea-level rise (Mengel & Levermann 2014).

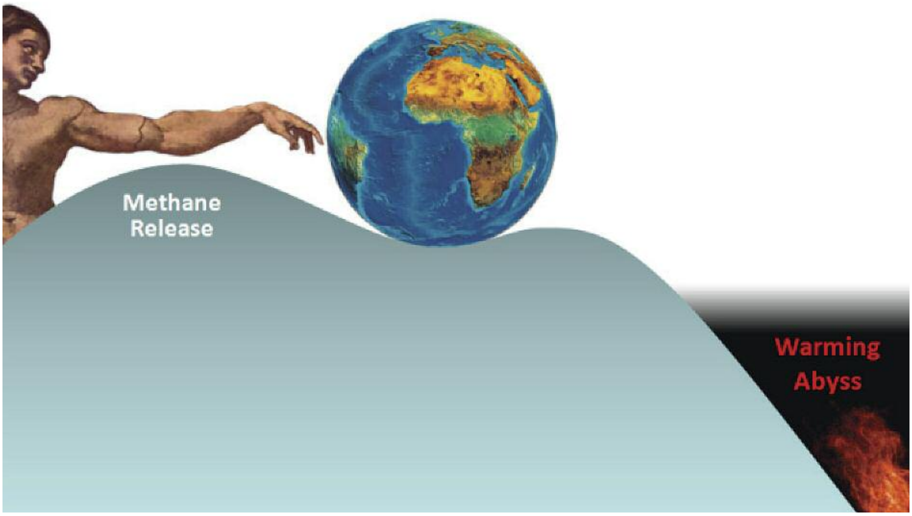

Figure 10: A Global Tipping Point? Methane release from ex-permafrost regions and oceanic shelves in the Arctic due to warming is a potential trigger for a runaway greenhouse effect: A self-enhancing process could set in because methane is a powerful greenhouse gas causing further warming and thus enhancing methane release even more.

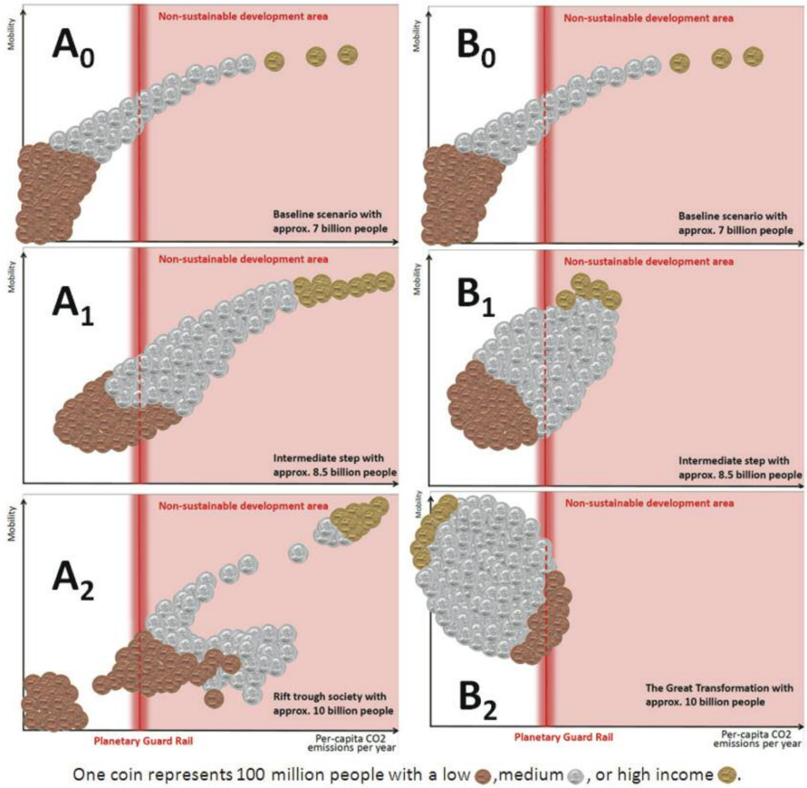

Figure 11: Alternative Development Paths. In this "development cartoon" prepared for WBGU (2014), income distribution, population development, per capita CO_2 emissions and wealth (represented here by the development indicator mobility) and their interrelations are all lined out for two alternative development strategies: While the traditional development paradigm (A_0-A_2) prescribes a shift towards a more carbon intensive lifestyle for everyone (A_1), a sustainable path (B_0-B_2) both reduces poverty and the carbon intensity of the lifestyle of the wealthy (B_1). Society therefore has the choice to either pursue traditional development strategies with the risk of tipping and breaking apart, not least because of the negative externalities of climate change (A_2), or to embrace the route to a Great Transformation, closing ranks and reaching global sustainability for both nature and humanity (B_2).

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