since the 1950s, aims at simply shifting this rather stretched cloud in a diagonal way by pumping even more fossil fuels into the global industrial metabolism: The rich will become disproportionally richer by this, but even the extreme poor will eventually benefit and get access to basic services such as mobility. So the theory goes, at least.

Even if this theory were intrinsically correct (in spite of mounting evidence against it; see the contribution of J. Stiglitz in this report), it would pathetically neglect the negative externalities accompanying climate change: When greenhouse gas emissions go through the roof in such a brute-force development scenario, dangerous global warming cannot be avoided anymore. In view of the 2°C guardrail and the associated finite carbon budget available for global civilization (WBGU 2009), the average per-capita & per-annum emissions allowance over the next fifty years is around 2-3 tons CO_2 eq. Our cartoon reflects the evident point that the diagonal upward stretching of the human cloud pushes the majority of the global population far into the non-sustainable realm (A_1). As a result, the entire situation becomes highly unstable and prone to "socioeconomic tipping events", as especially the poor have no means to cope with the dire impacts of climate change resulting from ever-rising greenhouse-gas emissions. Disparities grow further and further; eventually, the entire overstretched social fabric may come apart, as sketched in the cartoon (A_2).

There is an alternative to this gamble with nature and humanity though, as outlined in the right-hand part of Figure 11. In this scenario, the rich do not lead the global population into the non-sustainable domain beyond the 2-3 tons line, but are the first to *bend back* from greenhouse gas emissions (associated with mobility in our example)! In other words, the affluent become those change agents who ensure that the global population aims at respecting the climate guardrail on average (B_1). The reasons for such a "division of labor for sustainability" are compelling, since the rich (i) contribute by far the most to climate destabilization up to now, and (ii) have all the means to adopt lifestyles (e.g., working at home office) and technologies (e.g., electric cars) which are better for the environment. That avant-garde move should enable the less affluent to gain leeway in order to develop towards a better living standard in due course. This means that while leapfrogging unsustainable energy schemes is an option, in principle, for every society and every individual anywhere, *the responsibility for clean development is not with the poor, but with the wealthy*.

Note that humankind literally comes around in the final stage of our sustainability cartoon (B_2), where some of the more affluent people even pioneer negative-emissions mobility (using biofuels produced with carbon

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).

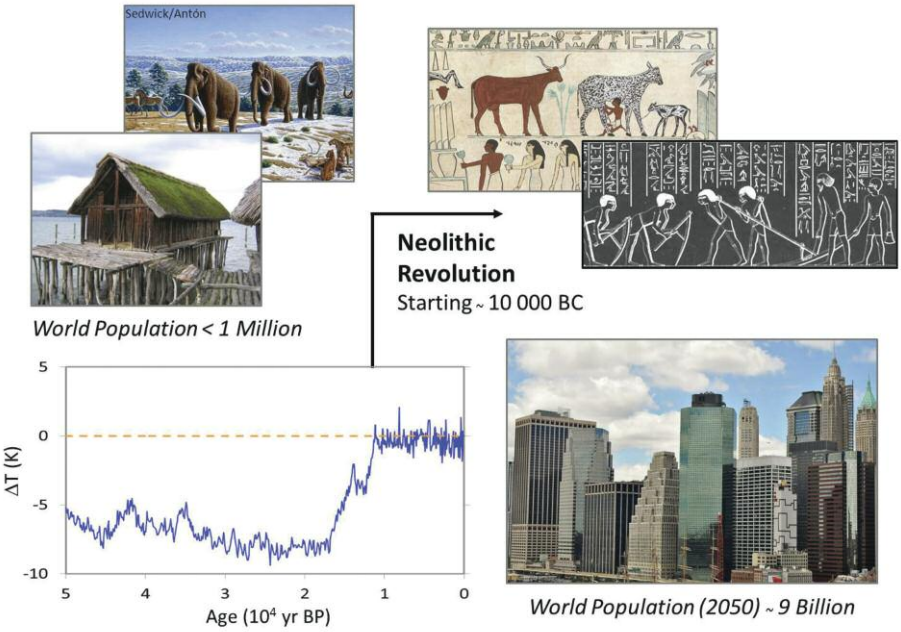

Figure 1: The Neolithic Revolution in the Holocene. With the onset of the stable climate of the Holocene some 12 000 years ago, small groups of human hunters and gatherers wandering the continents were given the opportunity to settle down. They practiced agriculture and domestication of plants and animals, 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).

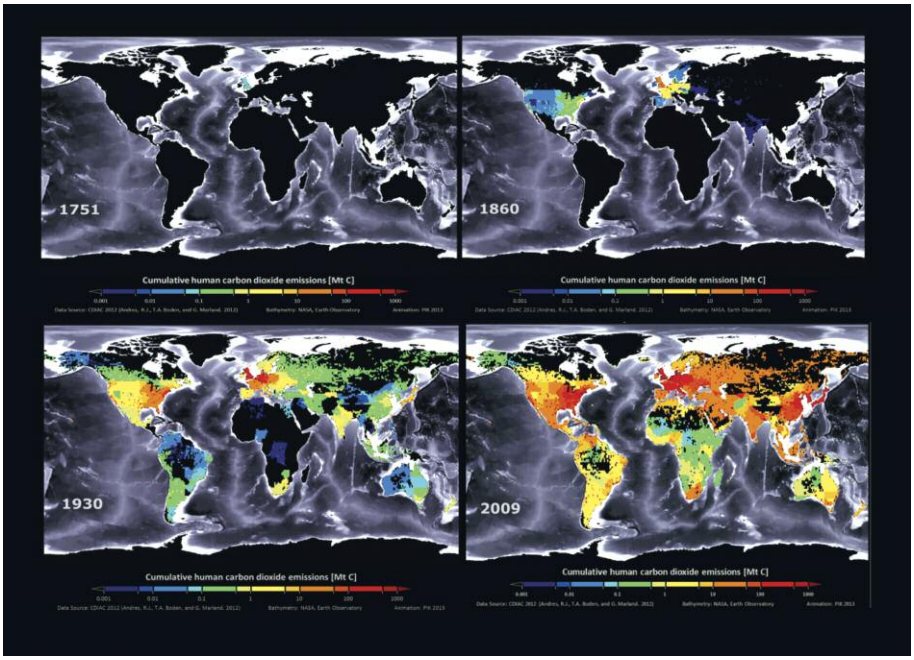

Figure 2: The "C-Story of Humankind": Cumulative Human Carbon Dioxide Emissions since the Industrial Revolution. Income, population density and cumulative emissions of carbon dioxide have undergone a remarkably parallel development since the industrial revolution, which originated in the textile industry 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 20th 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).

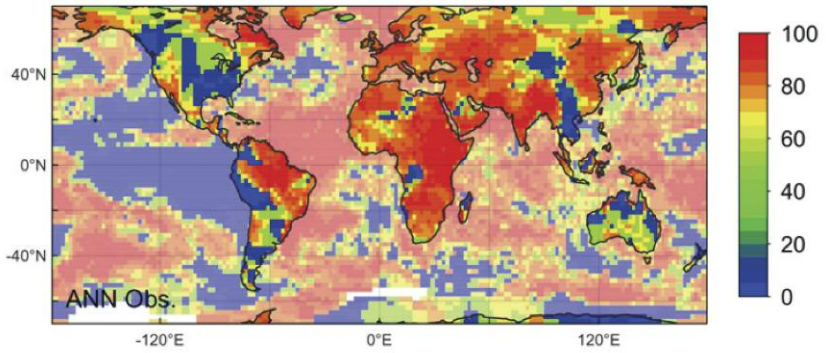

Figure 3: Heat Records due to Climate Change. Record-breaking monthly mean temperatures occur more often than could be expected from natural variability. The probability that such events in the last decade are due to climate change is about 80% in the global average (Coumou *et al.*, 2013).

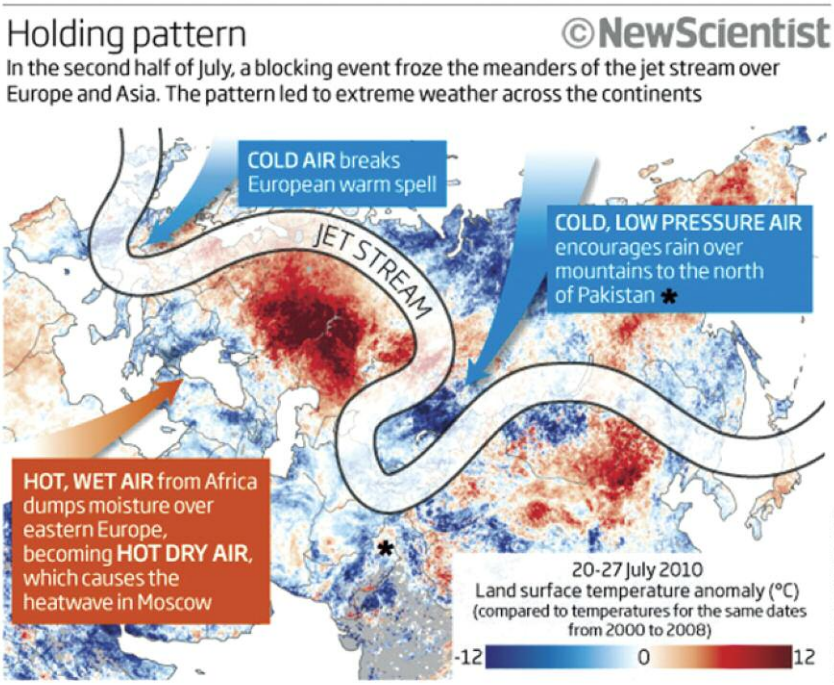

Figure 4: Synchronicity of Extreme Events. The Russian heat wave and the Pakistan flooding in 2010 are examples of synchronous extreme events that are tied to a blocking event in the atmosphere: the path of the jet stream freezes and high and low pressure systems stabilize resulting in constant local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

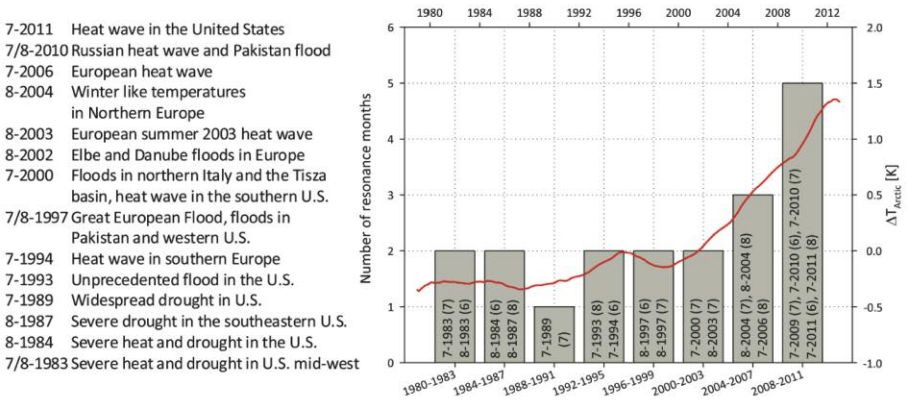

Figure 5: Increase in Quasi-Resonance Events. The increasing difference of surface warming between the Arctic and in the rest of the Northern Hemisphere (red line) as well as the number of July and August resonance months (grey bars, Petoukhov *et al*., 2013) are associated with extreme weather events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

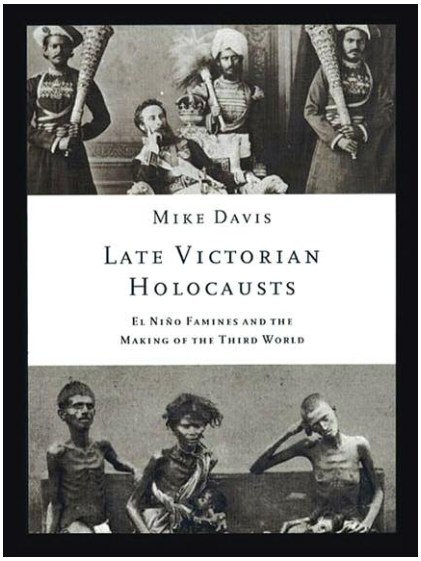

Figure 6: Worldwide Historical Consequences of ENSO Events. In the late 19th century, around 30-50 million premature deaths in India, China and Brazil were related to droughts and monsoon failures, floods and epidemic diseases. Historian Mike Davis attributes the resulting "climates of hunger" to the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

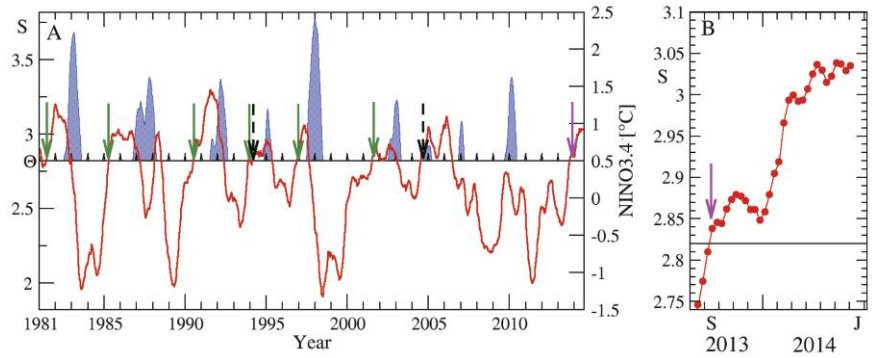

Figure 7: A Novel Method of Forecasting El Niño Events. The link strength *S* , describing teleconnections of temperatures between the El Niño basin and the rest of the Pacific (red curve), can be used as a very early warning bell for El Niño events (blue shaded areas) ringing at least one year ahead: 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).

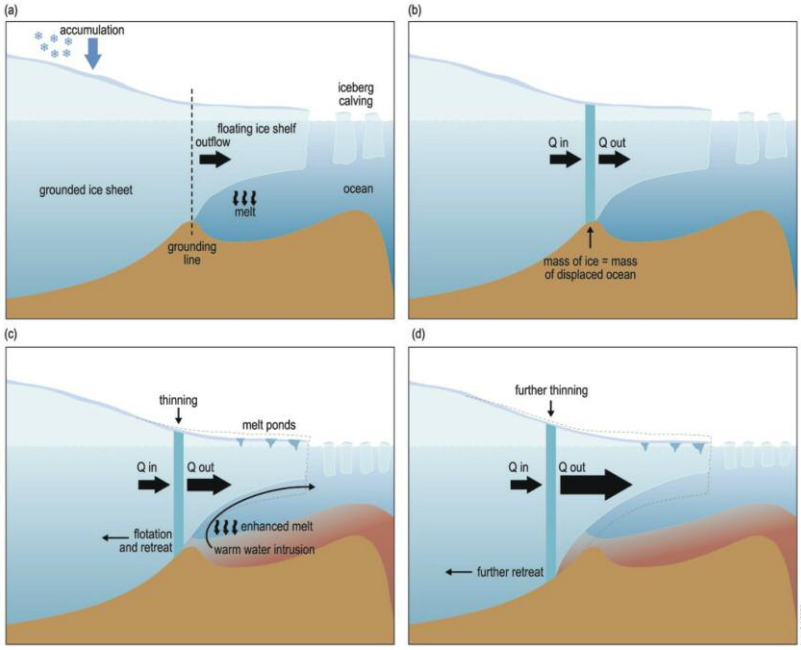

Figure 8: The Marine Ice Sheet Instability. The Marine Ice Sheet Instability (MISI) is the process leading to a potentially unstable retreat of a grounding line. (a) Profile of a marine ice sheet (b) Ice flux at the grounding line in steady state (c) Stronger outflow is triggered by ice-shelf melting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

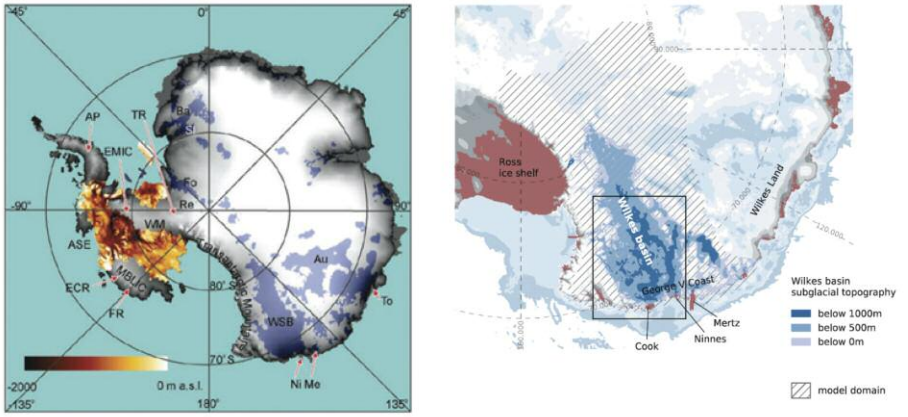

Figure 9: The Tipping Potential of the Antarctic Ice Sheet. Marine regions of the Antarctic ice sheet (i.e., areas where the ice sheet rests on a base below sea level, compare Figure 8) are potentially unstable. Left Panel: The marine West Antarctic ice sheet (red and orange colors) holds enough ice 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).

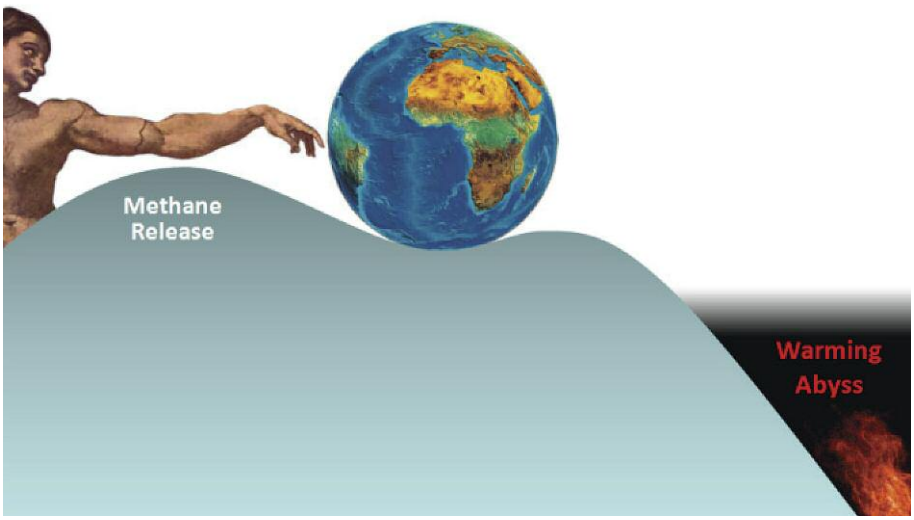

Figure 10: A Global Tipping Point? Methane release from ex-permafrost regions and oceanic shelves in the Arctic due to warming is a potential trigger for a runaway greenhouse effect: A self-enhancing process could set in because methane is a powerful greenhouse gas causing further warming and thus enhancing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

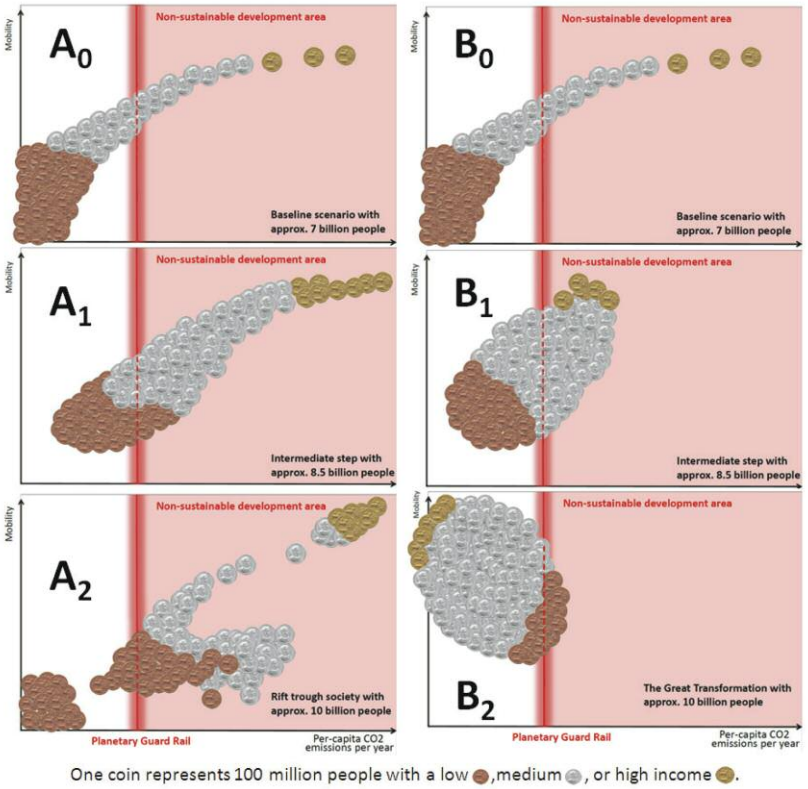

Figure 11: Alternative Development Paths. In this "development cartoon" prepared for WBGU (2014), income distribution, population development, per capita CO_2 emissions and wealth (represented here by the development indicator mobility) and their interrelations are all lined out for two alternative development 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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