

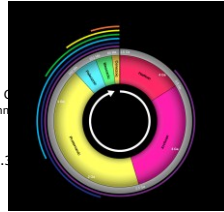


Yfirlit

- Skoðum (stuttlega) jörðina
 - Hvað hefur breyst
 - Hvað er að breytast
 - Stutt svar: allt
- Hér nota ég:
 - kár = þúsund ár = 1 000 ár
 - Már = milljón ár = 1 000 000 ár
 - Gár = milljarður ára = 1 000 000 000 ár

Jörðin myndast

- Jörðin myndaðist fyrir um 4.55 Gár
- Elstu lífverur (e. microbes) 3.45 Gár
 - Elstu óumdeildu umfr...
- Líf myndaðist við "jafnaraðæður"
- Súrefni í loftþjúp 2.3 Gár

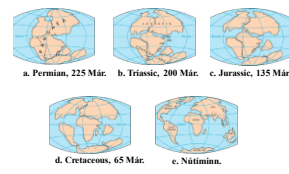


Plötuhreyfingar

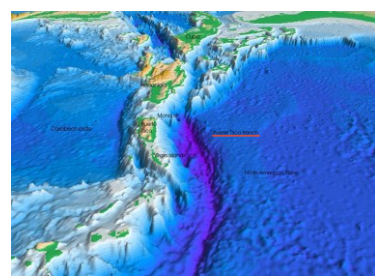
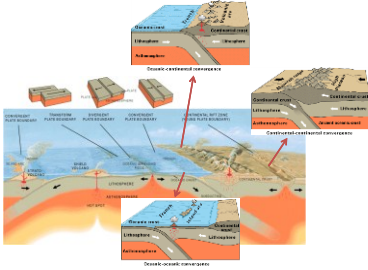
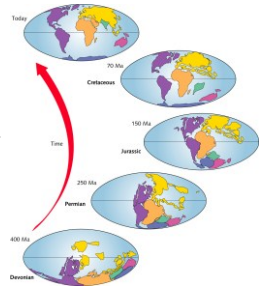
- Yfirborð jarðar samansett úr stórum "flekum"
- Kenning sett fram af Alfred Wegener kringum 1960
 - Sönnun þegar segulsvið sjávarskorpu mælt
- Færsla á flekamótum oftast um 50 – 100 mm/a



Plötuhreyfingar

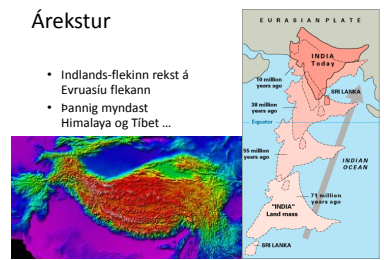


Plötu-hreyfingar



Árekstur

- Indlands-flekinn rekst á Evruasiu flekann
- Þannig myndast Himalaya og Tibet ...



Himalaya



San Andreas fault

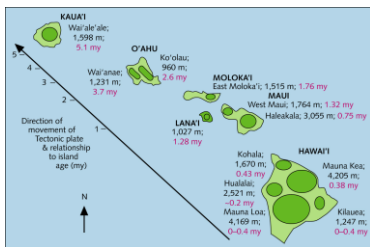


An aerial view of the San Andreas fault in the Carrizo Plain, Central California.

Relative motion of the Pacific and N-American plates ~46 mm a⁻¹

Heitir reitir – Hot spots

- Mikil eldvirkni
- Oft á miðjum plötum
- Einn undir Íslandi (?)
- Hawaii frægt dæmi

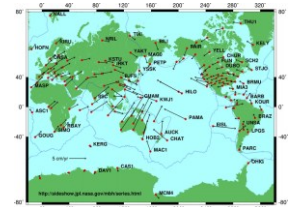


Jörðin – nú til dags



... er enn á hreyfingu

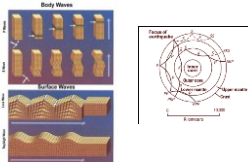
Plötuhreyfingar nú til dags



Samsetning möttulsins

- Líkön út frá mælingum á hraða og dreifingu skjálftabylgna
- Einnig fræðilegir útreikningar
- Tilraunir á rannsóknarstofum

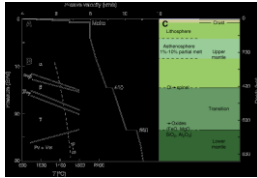
Skjálftabylgjur



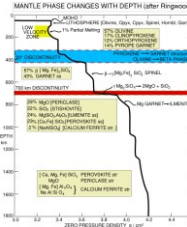
Dziewonski and Anderson (I)

- Average P-wave velocity vs. depth structure for the crust and upper mantle after Dziewonski and Anderson (1981) and Kennett et al. (1995).
- Mineral phase changes with increasing pressure and temperature. α = olivine, β = modified spinel, γ = spinel, Pv = perovskite, Mw = magnesio-wüstite, B-S = mantle geotherm from Brown and Shankland (1981).
- Mineral and state changes corresponding to boundaries in the mantle.

Dziewonski and Anderson (II)



Mantle phases



Uppruni vatns á jörðinni

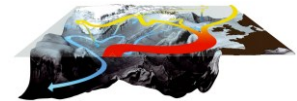
- Byrjaði allt saman við Miklahvelli.
- Dreifing sjaldgæfra gastegunda bendir til þess að **halastjörnur** (e. comets) og **uppgufun vatns frá móttli** (e. mantle outgassing) eigi jafnan þátt í vatni jarðar (50 – 50)
- Höf voru til staðar fyrir 3 Gár (3 · 10⁹ ár) síðan
– Setlög eru sönnun þess.

Hafstraumar (e. ocean conveyor belt)

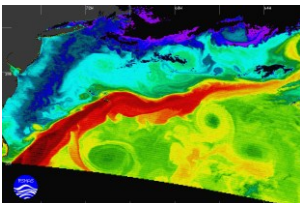


Breytingar í stjórnu meginlandanna hefur verið áhrif á dreifingu hita með hafstraumum, munni Pangea ...

N-Atlantshafíð

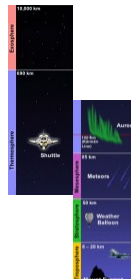


Golfstrumurinn



Lofthjúpurinn

- **Troposphere**
– The lowest layer of the atmosphere starting at the surface going up to between 7 to 10 km in the poles and 17 km at the equator with some variation due to weather factors. The temperature decreases as you go up and the air becomes thinner. The air is warmer at the surface. The air is warmer at the surface. The air is warmer at the surface. The air is warmer at the surface.
- **Ozonosphere**
– The ozone layer is the part of the Earth's atmosphere which contains relatively high concentrations of ozone. "Normally light" absorbs a few parts per million. much higher than the concentration in the rest of the atmosphere. It is concentrated in the stratosphere from approximately 15 km to 35 km above Earth's surface, though the thickness varies naturally and along latitude.
- **Stratosphere**
– Goes from 10 to 50 km range to about 50 km, temperature decreasing with height.
- **Mesosphere**
– Goes from 50 to 65 km, temperature increasing with height.
- **Thermosphere**
– The part of the atmosphere that is ionized by solar radiation. It plays an important part in atmospheric electricity and forms the outer layer of the magnetosphere. It has the potential to capture and hold charged particles, it influences radio propagation to distant places in the earth. It is located in the thermosphere.
- **Exosphere**
– Goes from 65 km up to 10,000 km, the moving particles that may migrate into and out of the magnetosphere or the solar wind.



Samsetning lofthjúpsinn

Gas	Volume
Nitrogen (N ₂)	780,840 ppmv (78.084%)
Oxygen (O ₂)	209,460 ppmv (20.946%)
Argon (Ar)	9,340 ppmv (0.9340%)
Carbon dioxide (CO ₂)	383 ppmv (0.0383%)
Neon (Ne)	18.18 ppmv
Helium (He)	5.24 ppmv
Methane (CH ₄)	1.745 ppmv
Krypton (Kr)	1.14 ppmv
Hydrogen (H ₂)	0.55 ppmv
Not included in above dry atmosphere:	
Water vapor (H ₂ O)	typically 1% to 4% (highly variable)



Tunglið

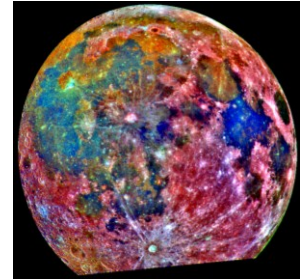


Myndun - margar tilgátur en, árektur fyrirbæris á stærð við Mars nú talið líklegast.

Myndaðist fyrir um 4.527 Gár, eða 30 – 50 Már eftir að jörðin myndaðist

Mynd af yfirborði tunglsins

- Samsett af 15 myndum með fólkskum litum frá 8. desember, 1992.
- Svæði sem virðast rauð tengjast lunar highlands
- Blue to orange shades indicate the ancient volcanic lava flow of a mare, or lunar sea.
- Purple areas found near the center are pyroclastic deposits formed by explosive volcanic eruptions.
- The fresh crater Tycho, with a diameter of 85 kilometers, is prominent at the bottom of the photograph, where part of the Moon's disk is missing.



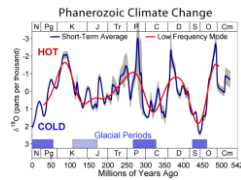
Væðurfar og þróun mannsins



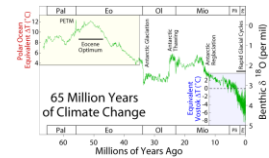
ThrostrTh@hi.is

Breytingar

- Síðustu 542 Már

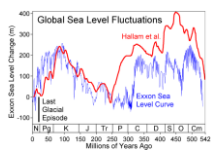


Hitastig (65 Már)

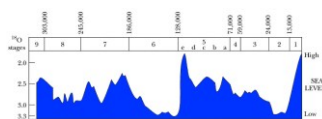


Færum nær tímabilinu sem tengist þróun mannsins

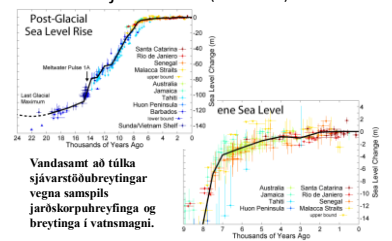
Sjávarstaða (542 Már)



Sjávarstaða 300 kár

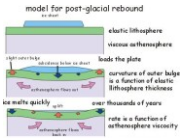


Sjávarstaða (24 & 9 kár)

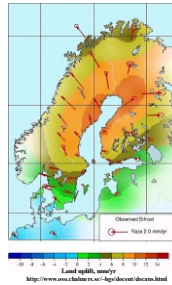


Vandasamt að túlka sjávarstöðubreytingar vegna samsþils jarðskorpupreyfinga og breytinga í vatnsmagni.

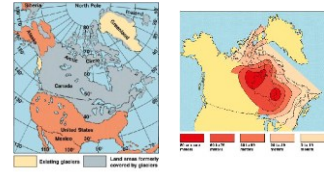
Rebound



Fennoscandia



Glacial rebound



Milankovitch cycles and Glaciation

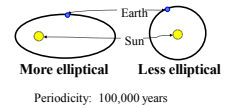
The three Milankovitch Cycles impact the **seasonality and location** of solar energy around the Earth, thus **impacting contrasts between the seasons**.

Milankovitch

- **Milutin Milanković** (1879 - 1958)



Eccentricity

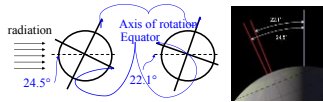


Reduces, or increases, the amount of radiation received at the Earth's surface in different seasons

Eccentricity

- Núna er mismunur í fjarlægð næst sólu og fjarst sólu um 3.4% (5.1 milljón km). Það samsvarar um 6.8% aukningu í sólgeislun.

Axial Tilt

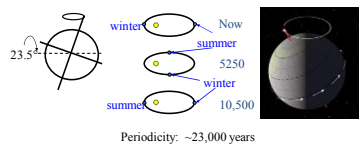


Periodicity: 41,000 years
 Today axial tilt is ~23.5 degrees, which largely accounts for our seasons. Because of the periodic variations of this angle the severity of the Earth's seasons changes. With less axial tilt the Sun's solar radiation is more evenly distributed between winter and summer.

Axial tilt - framhald

- **Ein tilgátan er sú að ef hornið er lítið vaxi jöklar.**
 - Þá verða vetur hlýrri, meiri raki í lofti og því meiri snjókoma.
 - Þar að auki yrðu sumrin kaldari og því minni bráðnun.
 - Nú til dags er hornið mitt á milli hámarks og lágmarks.

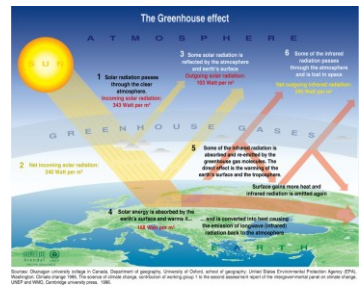
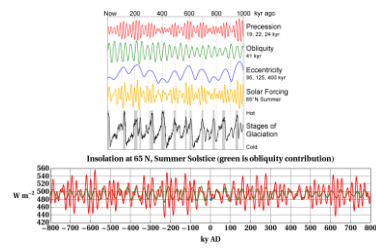
Precession



Precession

- Due to this wobble a climatically significant alteration must take place.
- Determines whether the Northern Hemisphere will experience winter when the Earth is furthest from the Sun and summer when the Earth is closest to the Sun.
- This coincidence will result in greater seasonal contrasts.

Milankovitch variations



Isotope ratios

- Define R as the ratio of heavy to light isotope
- R_0 as the standard reference value – Standard Mean Ocean Water (SMOW)
- Then,

$$\delta = 1000 \cdot \frac{R - R_0}{R_0}$$

Where δ is in parts per thousand, and always negative

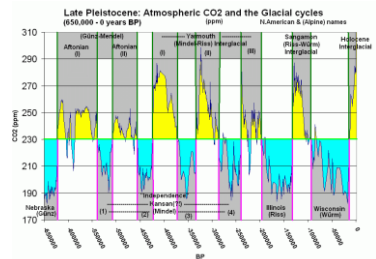
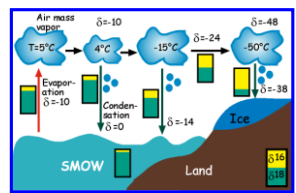
Ocean isotopes

- Nearly uniform composition
- Ratios are:
 $H_2^{16}O : HD^{16}O : H_2^{18}O$
 $0.9977 : 0.0003 : 0.0020$

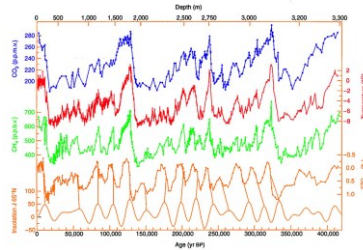
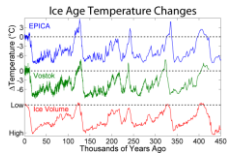
$\delta^{18}O$

- Then $R = O^{18}/O^{16}$
- Given as $\delta^{18}O$
- For Greenland, an approximate relation is
 $\delta^{18}O = 0.67 T - 13.7$
- Note, will depend on distance from source also
- Not very precise (closer inspection revealed)

$\delta^{18}O$ as a temperature proxy



Hitastig 450 kár, ískjarnar



Ískjarnar frá Grænlandi

- Ískjarnar sem boraðir voru niður á 3 km dýpi í Grænlandsjökli geyma upplýsingar um forneðurfur.
- Gögnin sýna að veðurfar breyttist mörgum sinnum mikið á mjög stuttum tímaskala (jafnvel áratug).

Litla ísöldin (The Little Ice Age)

- Víkingar yfirgáfu byggðir í Grænlandi þegar veður varð skyndilega kaldara fyrir u.þ.b. 700 árum síðan.
- Milli 1400 og 1850 höfðu kaldir vetur mikil áhrif á landbúnað, efnahag, og stjórnmál í Evrópu.

Myndlist sýnir áhrifin



The Medieval Period

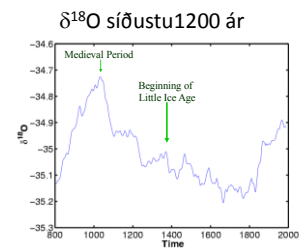
- Hlýnun átti sér stað fyrir um 1,000 árum síðan (árin 800 – 1300).
- Þessi atburður var ekki nánda nærri eins stór og fyrri atburðir, en hafði engu að síður mikil áhrif:
 - Víkingar settust að á Grænlandi.
 - Vínberjarækt á suður Englandi

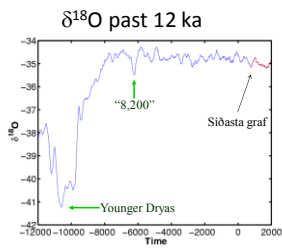
The 8,200-Year Event

- Snögg kölnun átti sér stað fyrir 8 200 árum.
- Sú kölnun var ekki eins mikil og Younger Dryas (sjá á eftir), og varði aðeín í um 100 ár.
- En, ef svipaður atburður ætti sér stað nú til dags myndu afleiðingarnar verða stórbrotnar.

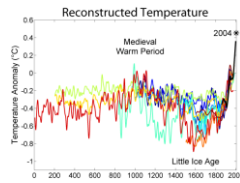
The Younger Dryas

- Fyrir um 12 700 árum lækkaði hitastigið við N-Atlantshaf snögglega um 5°C og hélst þannig í um 1 300 ár, áður en aftur hlýnaði snögglega.

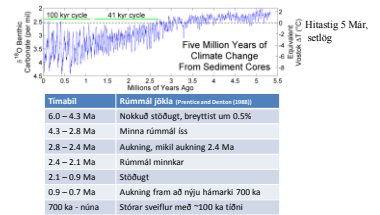




LIA og MWP



Ísaldir og maðurinn



Nokkrir veðurfarsatburðir

Tímabil	Veðurfar	Mannskipan	Veðuraleiður
16 ka	Siðari hluti ísaldar	Cro-Magnons í Evrópu	Jöklar höfðu hratt
13 ka	Hýmnar	Fyrstu byggðir í NA Síbera	Sjávarstaða hækkar
11 ka	Kalt (Younger Dryas)	Hellalís í Niaux, Frakklandi	Kalt í Evrópu þvert í Ású
9 ka	Hýmnar	Búskapur í SA Ású	Meiri raki í lofti
6 ka	Kólnar		
4 ka	Hýmnar	Búpeningur í Sahara	
3 ka		Bæjir í Egyptalandi og Mesópótamíu	Þurrkar í Sahara, Egyptalandi og Mesópótamíu

Fagan, 2004

Ísaldir og hlýskeið

- Núverandi hlýskeið byrjaði fyrir um 15 kár.
- Siðasta þar á undan 130 – 117 kár.

Ísaldir - Afríka

- Hitastig fellur um ~ 5°C
- Þurrara og vindasamara

Gresjur - savannah

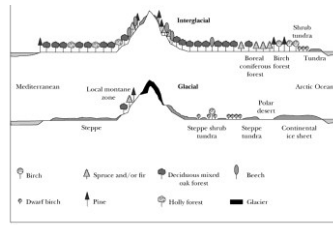
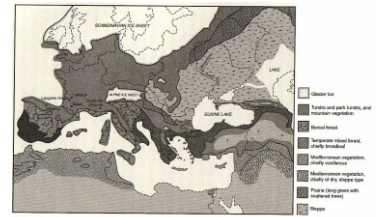


Fig. 2.2. (c) Representation of the vegetation during an interglacial and during a glacial period, in a north-south section through Europe. (Van der Hammen et al., 1971.)

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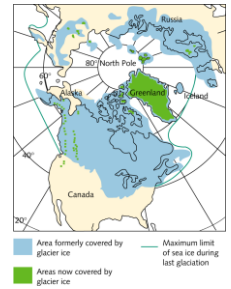
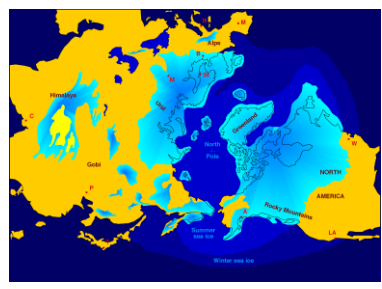
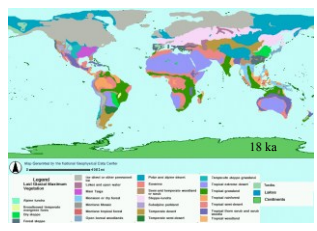
Ice age Europe



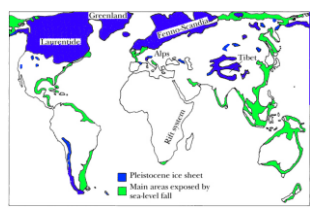
Map of Ice Age Europe.

Fagan, 2004

Gróðurfar á síðasta jökulskeiði

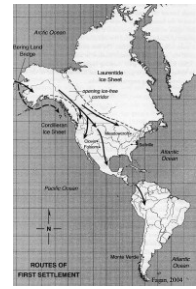


Lækkun sjávar

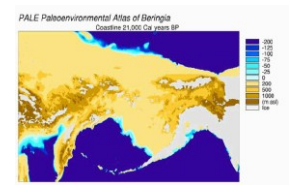


Routes of settlement

Through landbridge in the Bering strait N-America, through to S-America.



Beringa landbrú



Sahara region

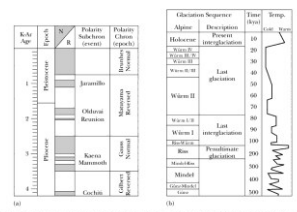
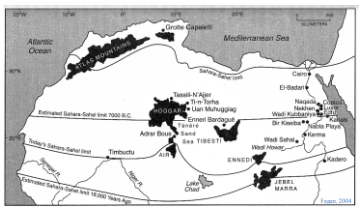


Fig. 2.1. The paleomagnetic chronology of human evolution over the Pleistocene. The Earth's geomagnetic field is known to have gone through a series of complete reversals in its polarity. At various times in the geologic past, its magnetic field has been directed, as it is today, toward the north (normal polarity) and at other times toward the south (reversed polarity). Short-term magnetic reversals of opposite polarity within such paleomagnetic "epochs" are called "events." In (a), the normal magnetic polarity epochs and events are shaded; reversed magnetic epochs and events are white. Shown expanded in (b) are the Alpine glacial sequences and corresponding temperatures over the past 500,000 years (see text and Table 2.1). (G. Brown, 1992.)

Áhrif veðurfars á manninn

Hraðar breytingar í veðri (veðurfari):

- þróunarpresa á fjölbæfni
- Breytingar á gróðri
- Hraðar breytingar (áratug) → breytt fæðuframboð

Veður → maður

- Kólnun veldur ósamfelldum kjörsvæðum
– Smærri samfélög myndast
- Blandast síðan saman þegar aftur hlýnar

Aðlögun

- Löngu fyrir 8 Már voru plötur á sínum stað, en Himalaya að rísa og sigdældin (rift valley) í Afríku að myndast.
- Afríka verður almennt kaldari og þurrari
- 5 – 1.6 Már, sveiflur í hitastigi
- 2.8 Már ísaldir, 40 kár lotur
- 900 kár, 100 kár lotur
– Mesta aukning í heilastærð síðustu 700 kár, sami tími og miklar sveiflur í veðurfari

Aðlögun (II)

- Elstu ummerki um notkun elds ~450 – 300 kár
- Nálir úr beini, 30 – 26 kár

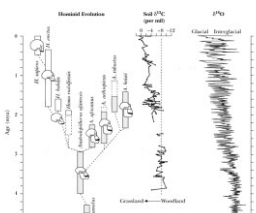
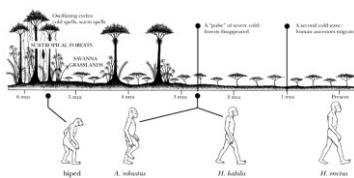


Fig. 2.9. (a) Temporal relations between changes in one scenario of hominin evolution, East African vegetation, and glacial ice volume. Step-like increases in African aridity at about 2.8, 1.3, and 1.0 mya may be related to significant speciation events in early hominin evolution. Increased regional aridity near 1.7 mya is supported by soil carbonate stable isotopic evidence ($\delta^{13}C$ values), and general cooling trends through the Plio-Pleistocene are evident in the oxygen isotope ($\delta^{18}O$) values. (From Adolphson, 1995.)

Veðurfar og þróun



Nútíminn

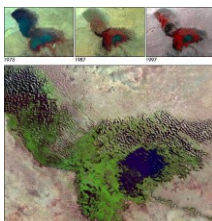
- Allir vilja “beach-front property”
- Dubai - UAE

Chad vatnið

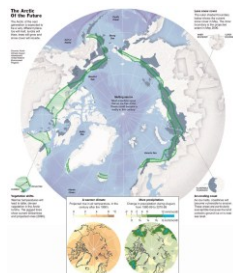
- Dæmi um hvernig umhverfið getur breyst mikið á stuttum tíma



Chad vatnið - myndir



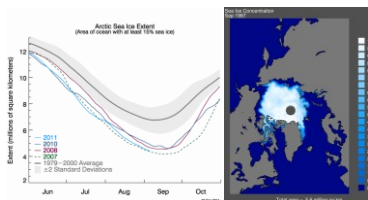
Norðhvelið í framtíðinni



Sea ice minimum 2007



Sea ice



Framtíðin

- Breytilegt gegnum tíðina hvað telst glæsileg framtíðarsýn !
- Áramótakveðja dagblaðs frá 1922



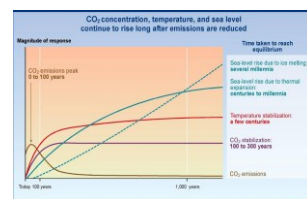
Auglýsing – ekki svo gömul (!)



Back to the future



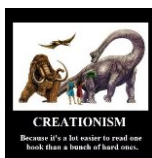
CO2 – Temp – Sea level



Framtíðin... ?



Sköpunarkenningin



ENDIR

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