






Om klimatfrågan i ljuset av mätdata och klimatmodeller; går de ihop?

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Three definitions of climate:

The average weather

The statistical description of weather in terms of the mean and variability - of relevant quantities - over a period of time (30 years is defined as the "climate normal period" by the World Meteorological Organization).

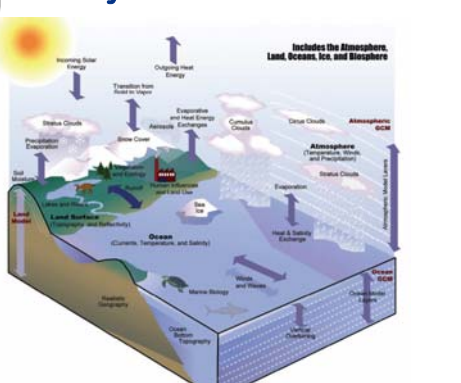
The state, including a statistical description, of the *climate system*.








Klimatsystemet



Includes the Atmosphere, Land, Ocean, Ice, and Biosphere

Karl and Trenberth, 2003

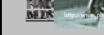


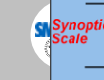





Klimatmätningar ger data

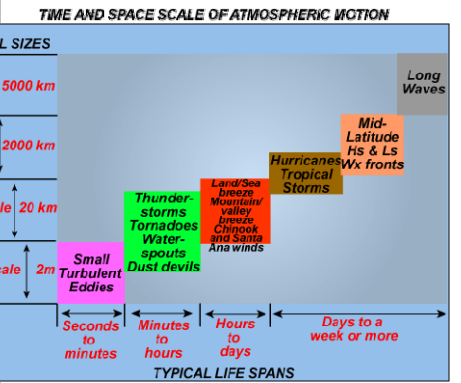






TIME AND SPACE SCALE OF ATMOSPHERIC MOTION



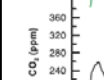
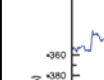
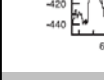
TYPICAL SIZES

- Global Scale: 5000 km
- Synoptic Scale: 2000 km
- Mesoscale: 20 km
- Microscale: 2m

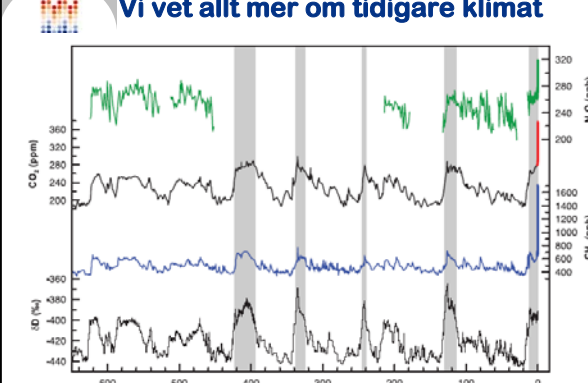
TYPICAL LIFE SPANS

- Long Waves: Days to a week or more
- Mid-Latitude Hs & Ls: Hours to days
- Hurricanes/Tropical Storms: Minutes to hours
- Thunderstorms/Tornadoes/Water-spouts/Dust devils: Seconds to minutes
- Small Turbulent Eddies: Minutes to hours
- Land/Sea breeze/Mountain valley breeze/Chinook and Santa Ana winds: Hours to days



Vi vet allt mer om tidigare klimat



CO₂ (ppm)

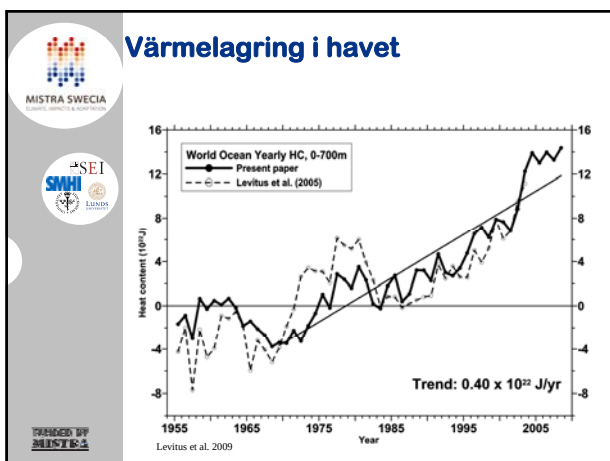
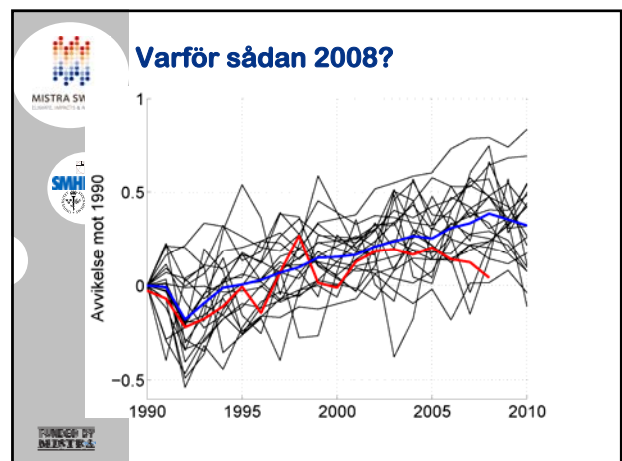
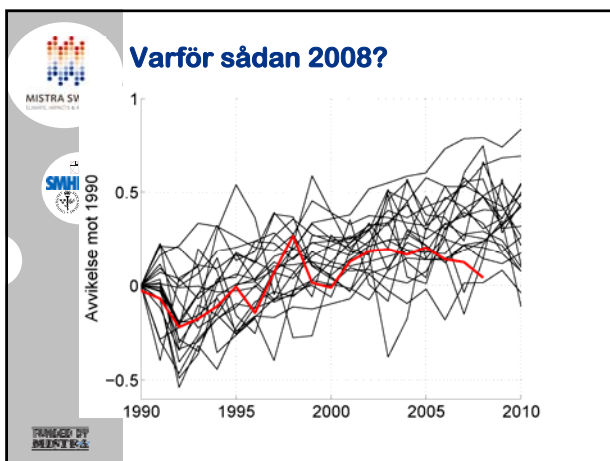
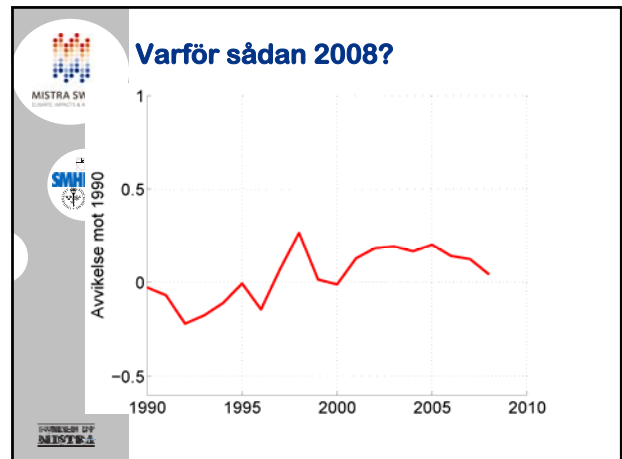
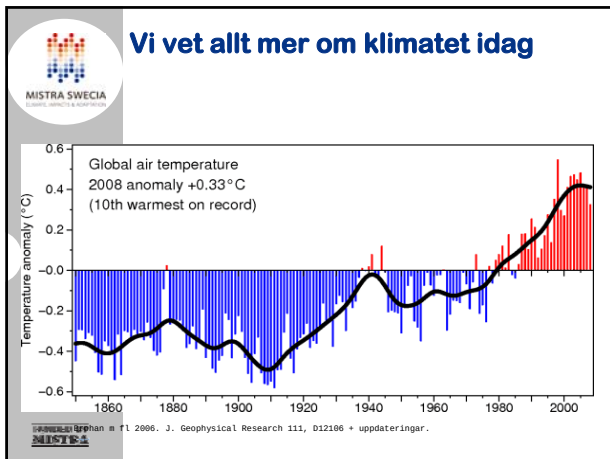
CH₄ (ppb)

N₂O (ppb)

Time (thousands of years before present)

IPCC, AR4/WG I (2008), Kap 6.





- Värmelagring i havet**
- Temperaturförändring(ar)
 - Glaciärer tinar
 - Havsytenivån höjs
 - Havsisäck (Arktis) minskar
 - Förändringar i naturliga system
 - ...

FN:s klimatpanel 2007: "Assessment Report 4" (AR4)

Observationer visar entydigt på en pågående uppvärmning

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Klimatsystemet

Includes the Atmosphere, Land, Oceans, Ice, and Biosphere

Key processes shown: Incoming Solar Energy, Outgoing Infrared Energy, Evaporation and Heat Exchange, Condensation, Precipitation, Snow Cover, Ice Cover, Land Surface (Vegetation and Land Use), Ocean (Currents, Temperature, and Salinity), Heat & Salinity Exchange, Vertical Mixing, Turbulent Exchange, and Clouds (Stratus, Cumulus, Cirrus, Stratocumulus, Altostratus, Nimbostratus, Cumulonimbus).

Source: Karl and Trenberth, 2003

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"Primitive Equations"

$$\frac{\partial u}{\partial t} + \vec{V} \cdot \nabla u + \omega \frac{\partial u}{\partial p} - f v + \frac{\partial \phi}{\partial x} = F_x$$

$$\frac{\partial v}{\partial t} + \vec{V} \cdot \nabla v + \omega \frac{\partial v}{\partial p} + f u + \frac{\partial \phi}{\partial y} = F_y$$

$$\frac{\partial \phi}{\partial p} = -\alpha$$

$$\frac{\partial T}{\partial t} + \vec{V} \cdot \nabla T + \omega \frac{\partial T}{\partial p} - \alpha \omega / C_p = Q / C_p$$

$$\nabla \cdot \vec{V} + \frac{\partial \omega}{\partial p} = 0$$

$$p \alpha = R T$$

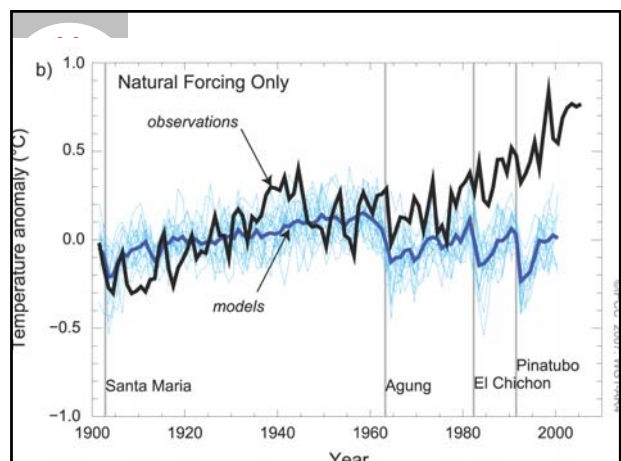
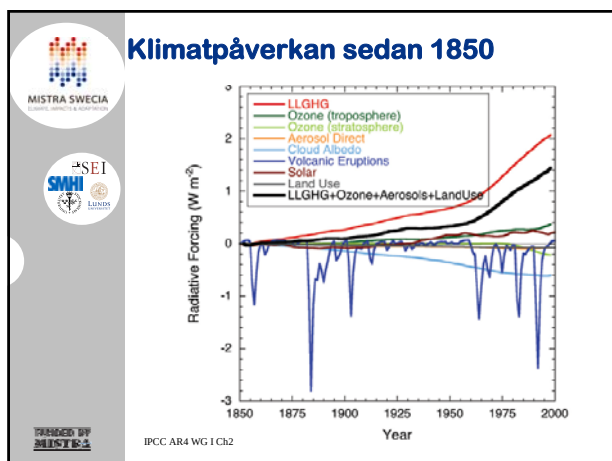
$$\frac{\partial q}{\partial t} + \vec{V} \cdot \nabla q + \omega \frac{\partial q}{\partial p} = S_q$$

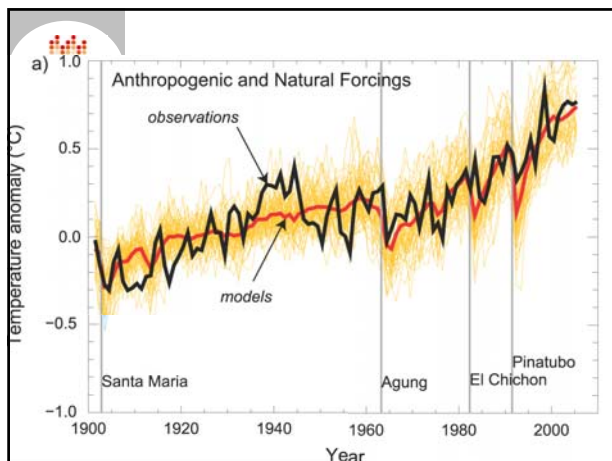
u, v, ω, T, α, Φ, and q

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Systemets fysikaliska karakteristika

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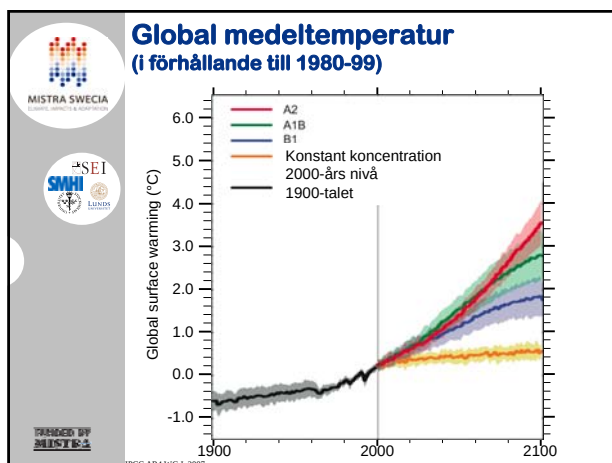
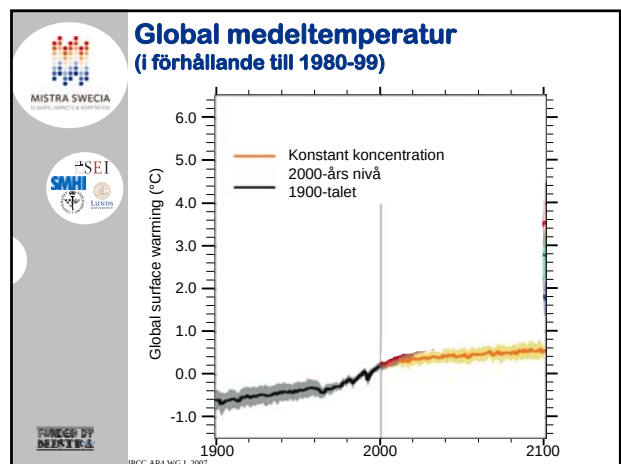
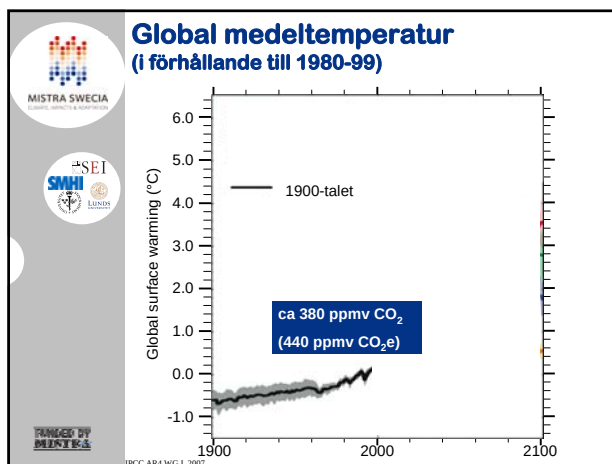


**FN:s klimatpanel 2007:
"Assessment Report 4" (AR4)**

Observationer visar entydigt på en pågående uppvärmning

Det mesta av uppvärmningen sedan mitten på 1900-talet beror mycket sannolikt på människan

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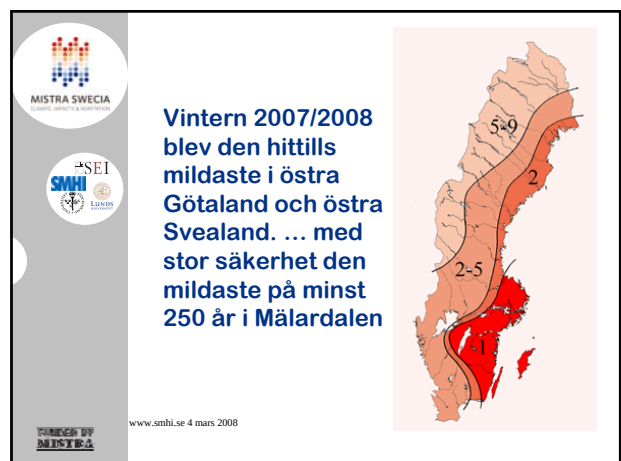
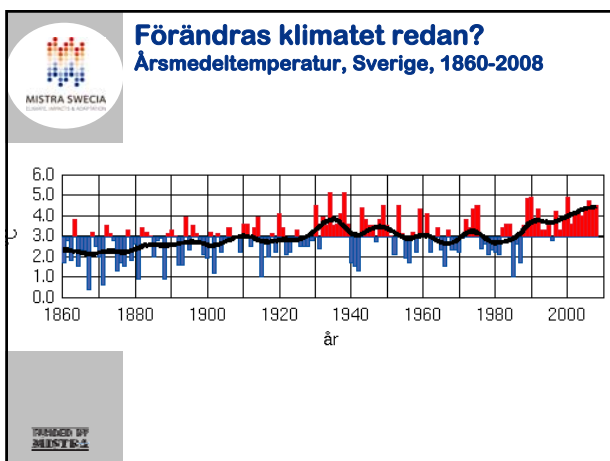
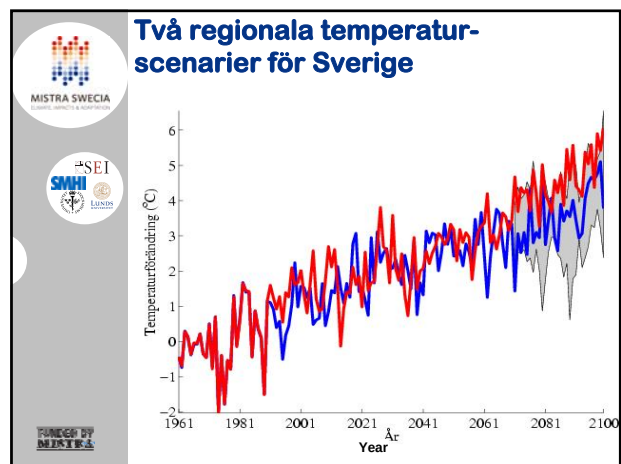
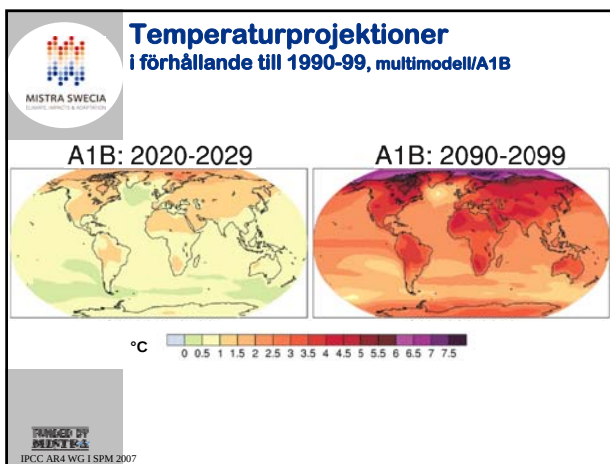
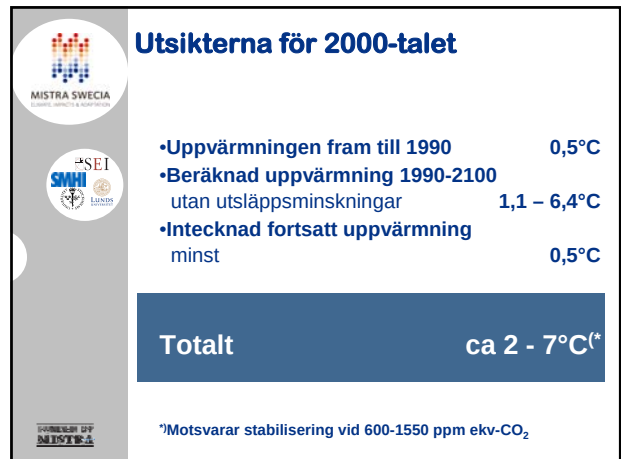
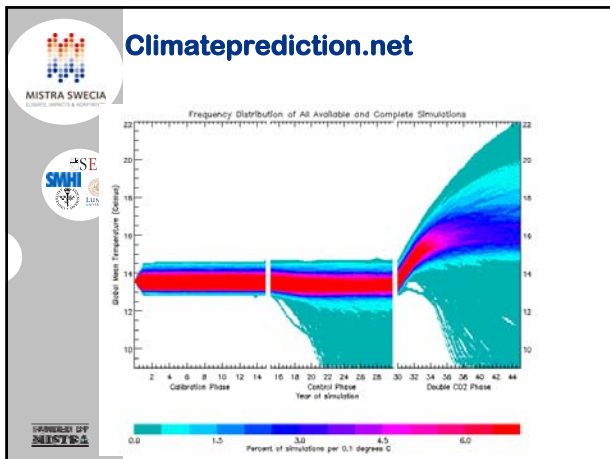
**Exempel av parameter-
osäkerhet**

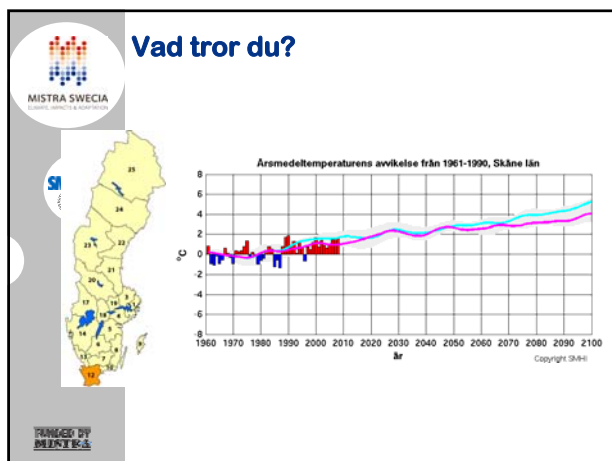
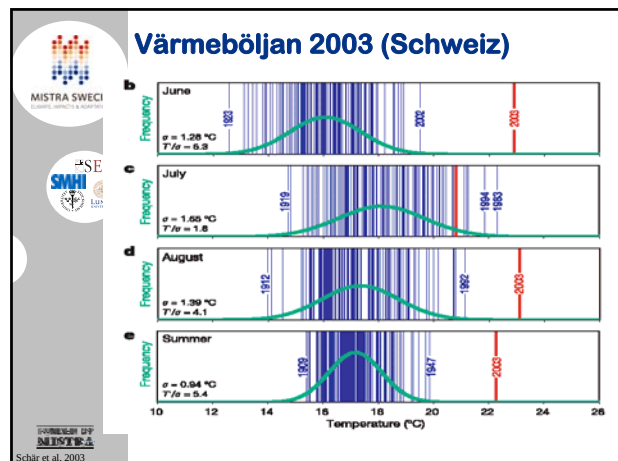
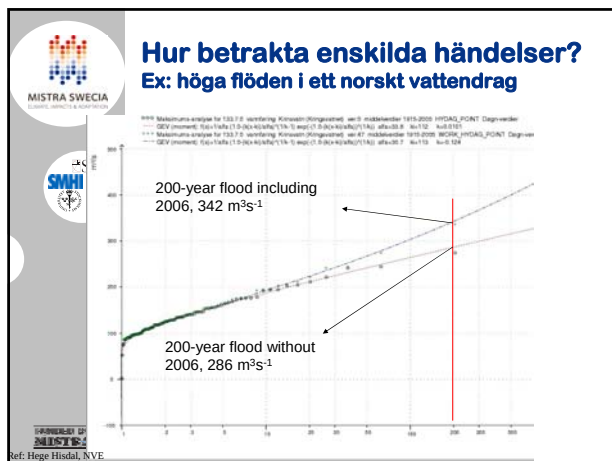
- Critical Relative Humidity [RHcrit]
- Accretion constant [CT]
- Condensation nuclei concentration [CW]
- Ice fall velocity [VF1]
- Entrainment coefficient (EntCoef).
- Empirically adjusted cloud fraction (EACF).

Parameter	Lågt värde	Standard värde	Högt värde
VF1	0,5	1,0	2,0
CT	5,00E-05	1,00E-04	4,00E-04
RHcrit	0,6	0,7	0,9
CW (hav, land)	1,00E-04 2,00E-05	2,00E-04 5,00E-05	2,00E-03 5,00E-04
EntCoef	0,6	3	9
EACF	-	0,5	0,6

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Source: climateprediction.net





Var är Laplaces demon när den mest behövs?

Pierre-Simon Laplace (1814): if it knew the precise location and momentum of every atom in the universe then it could use Newton's laws to reveal the entire course of cosmic events, past and future.

- Några frågor för statistiker...**
- Klimatsystemets interna variabilitet
 - Förändringar?
 - Förändringar i extremer/återkomsttider?
 - Konsistens mellan fysikaliskt relaterade data (förändrat klimat, attribution)?
 - "Sampling" / karakterisering av osäkerhet i data och i modellering