Dr.philos. Thesis

Harald Yndestad

The Lunar nodal cycle influence on the Barents Sea

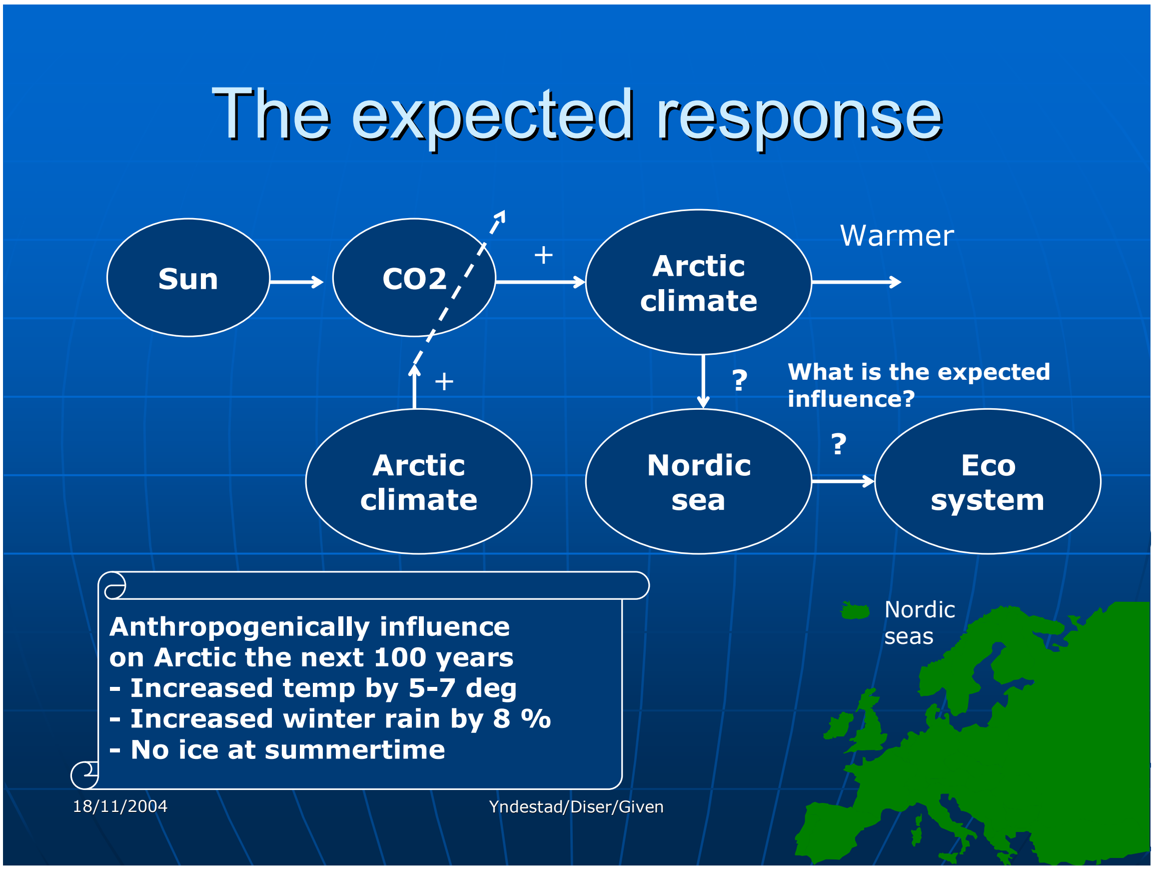
Given Trial

The response of the ecosystems of the Nordic Sea to climate change

Time: 14:30 25.11.2004

Department of Industrial Ecology
and Technology Management
Norwegian University of Science and Technology

The expected response



The question:

"What is the expected response on the ecosystem in the Nordic Seas from the expected climate change?"

"The talk should cover both expected changes to the physical oceanography under anthropogenically-induced climate warming based on climate model forecasts and the anticipated changes these will have on the marine ecosystem, especially fisheries, but not exclusively. The later can be speculative based upon observed responses of the components of the ecosystem to climate variability."

The expected climate change:
The research program Arctic Climate Impact Assessment (ACIA) has recently published a report about climate change. The Report publishes the expected climate change, mainly from increased CO2, caused by human activity. According to this report we may expect:

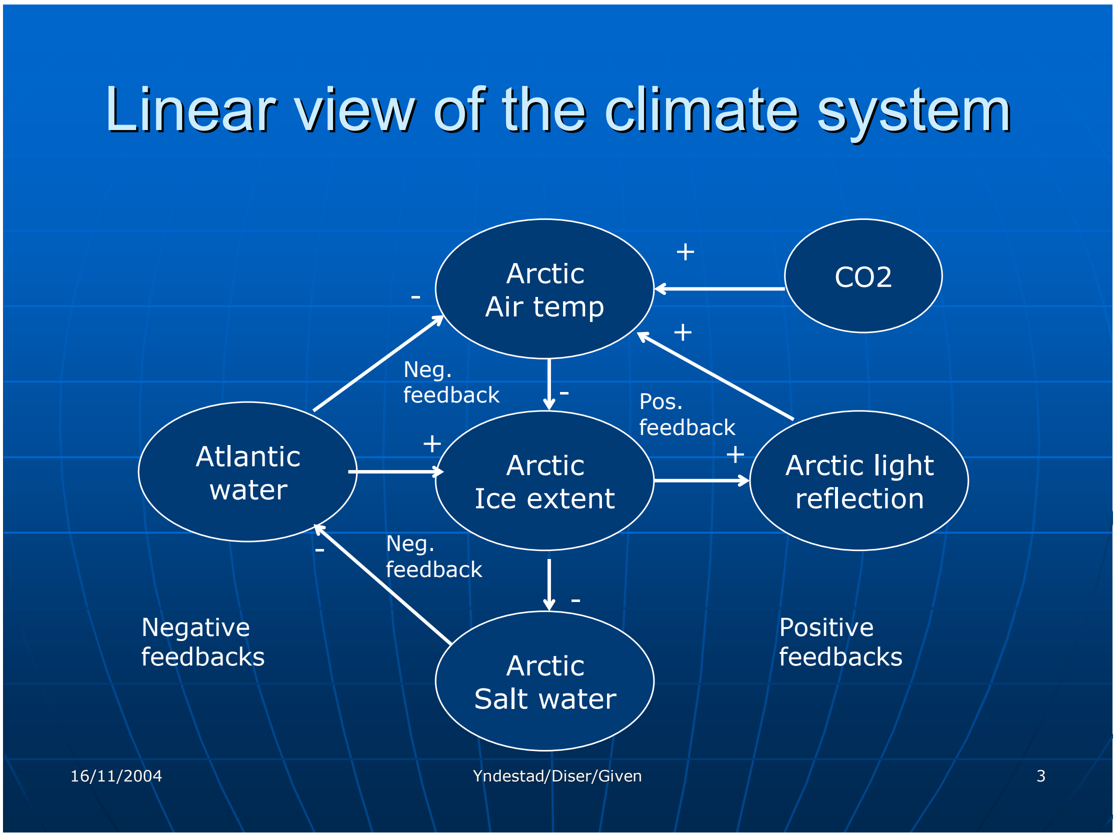
1. The temperature in the Arctic will increase 5-7 degrees the next 100 years.
2. Rain in the Arctic will increase by about 8 percent.
3. Most of Artic ice will be gone in the summer time.

This presentation

To give some possible answers to this question I have to:

1. Relate the question to some findings in the data from my thesis
2. And use some data outside the thesis

A Linear view of climate change



A simplified autonomous dynamic system
To get some ideas about the fundamental dynamics, it may be useful to start with a linear view and study some feedback loops in an autonomous dynamic system.

This slide represents a simplified model. If there is more CO2, it is expected to be a warmer air temperature over the Arctic.

Some feedbacks loop

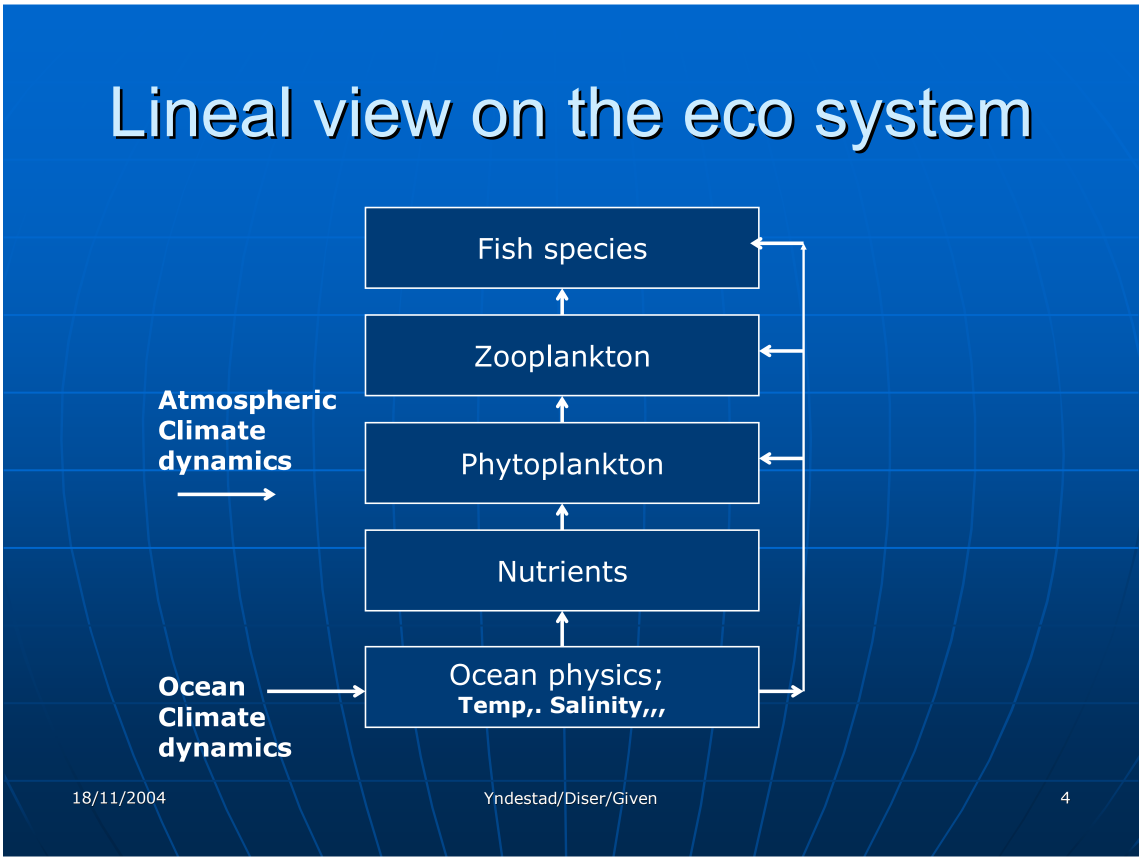
1. Light driven positive feedback: Warmer air temp, less ice extent, less light reflection in summer, and warmer air temperature
2. Ocean driven negative feedback: Warmer air temp, less ice extent, less salt water, less sinking water, less supply of new warm Atlantic water, more ice extent, and colder air temperature.
3. Air driven negative feedback: Warmer air temp, less ice extent, less salt water, less sinking water, less supply of new warm Atlantic water, less transfer of heat from water to the air in the winter, and colder Arctic air temperature.
4. Changes in sinking water will change complex deep-water circulations

Summary
So, what is the excepted total dynamics from these feedback loops?

1. This simple analysis gives on answer
2. The differences in masses, indicates the positive feedback will introduce a short warm period.

Then the global warming is a potential trigger to introduce a longer cold period, caused by a longer oscillation period in larger the water masses.

Linear view on the eco system



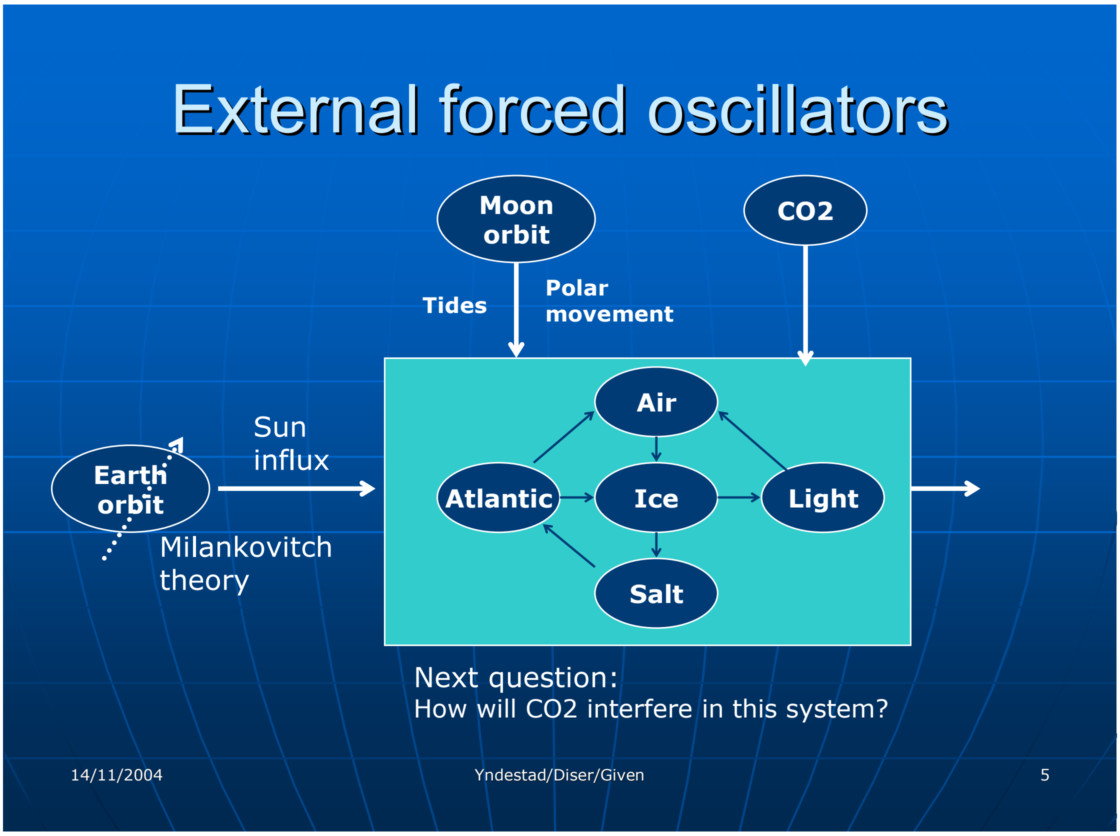
The eco system
This slide shows some relations between different elements in the food web. There is a change of events from ocean physics to nutrients, phytoplankton, zooplankton and to fish species. Climate change then will primary influence ocean physics, and secondary all levels in the food chain.

Linear relation
Climate change then will
1. Change the vertical water circulation
2. Which will influence the density of nutrients
3. This may alter the Phytoplankton composition
4. Which will change density of zooplankton populations
5. Which will influence the recruitment of different fish species

Summary
To understand the eco system, we have to understand
1. The autonomous dynamics between all levels in the food chain
2. Climate change as a forced external pressure to change the eco system

So, what do we expect from the forced climate change.

External forced oscillators



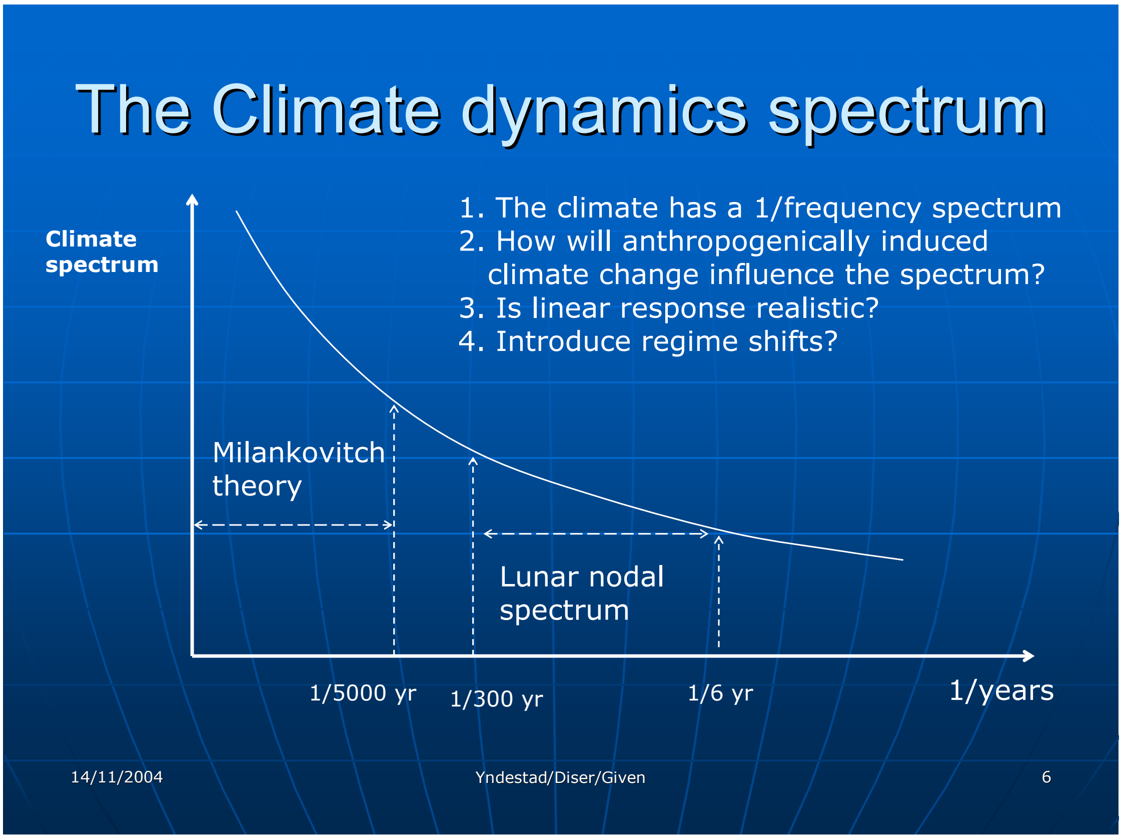
Climate change has an autonomous dynamic property, but this dynamic is controlled by external oscillating forces. This slide show a simplified model.

The long-term dynamic change
The long-term climate dynamics change is controlled by an oscillating influx from the Sun, controlled by an oscillating Earth orbit around the Sun. This control is known as the Milankovitch theory.

The lunar nodal cycle
Shorter changes in the Moon orbit around the Earth, causes a spectrum of periodic disturbances on the Earth. Changes in the gravity between the Moon and the Earth introduce fluctuations in tides and the Earth rotation.

This thesis
This thesis presents some findings, about how these lunar nodal cycles influences the Biomass in the Barents Sea.

The climate dynamics spectrum



The climate dynamics spectrum
The climate dynamics has a power density spectrum

1. The power spectrum is falling by about 1/frequency
2. The Milankovitch theory represents periods between about 5 to 300 thousand years.
3. The Lunar nodal spectrum has periods from about 6 to 300 years.

What may we expect from this external force model?

1. The Milankovitch theory, causes a long-term energy influx oscillation on Earth
2. The lunar nodal cycles, causes a long-term oscillation disturbance on Earth

What is the expected influence on the eco system?

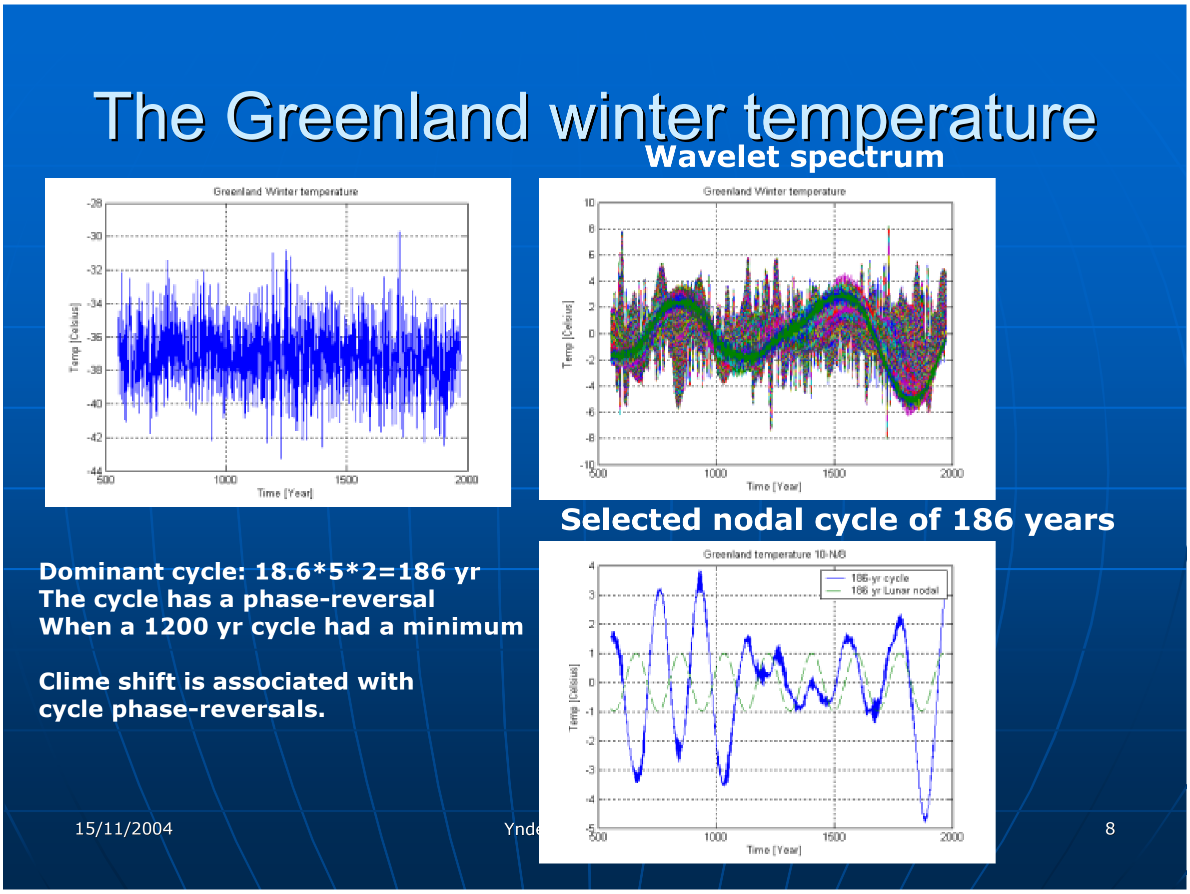
1. The eco system is forced by the long-term climate power spectrum falling 1/f
2. This means the eco system in the Nordic Seas have no final state
3. The eco system dynamics is dependent on the time scale
4. Small changes in pressure have much influence, when the pressure stays over a long period.
5. A small oscillating pressure in the same direction, is more important than the many non-correlated influences.

What about the anthropogenically-induced climate warming influence?

1. It may reduce the natural oscillation in the Nordic Seas
2. It may amplify the natural oscillation in the Nordic Seas

3. It may introduce a new spectrum, or a regime shift

The Greenland Temperature



The data series
This slide shows the estimated annual winter temperature at Greenland in the period 550 to 1990. The time series was estimated from ice cores. I got the time series for prof. Bo Vinter at Department of Geophysics, Niels Bohr Institute, Copenhagen. The analysis is not yet published.

The wavelet spectrum
The wavelet spectrum of the time series shows that:

1. There is a spectrum from the 18.6-yr lunar nodal cycle of about 93,186 and 672 years
2. The 186-yr cycle has a phase-reversal when the 672-yr cycle changes from a negative state.

Ninety years ago, the Swedish oceanographer Otto Pettersson explained long-term clime change by long-term changes in lunar orbit cycles, which introduced long-term tides. He predicted a minimum in 1433. The same period we had the “little ice age”.

If we study this wavelet analysis more closely, it shows that at the same time

1. the 672-yr cycle changes from a negative state to a positive state
2. the 186-yr cycle changes from a positive to a negative state
3. the 186-yr cycle has a phase-reversal in the same period

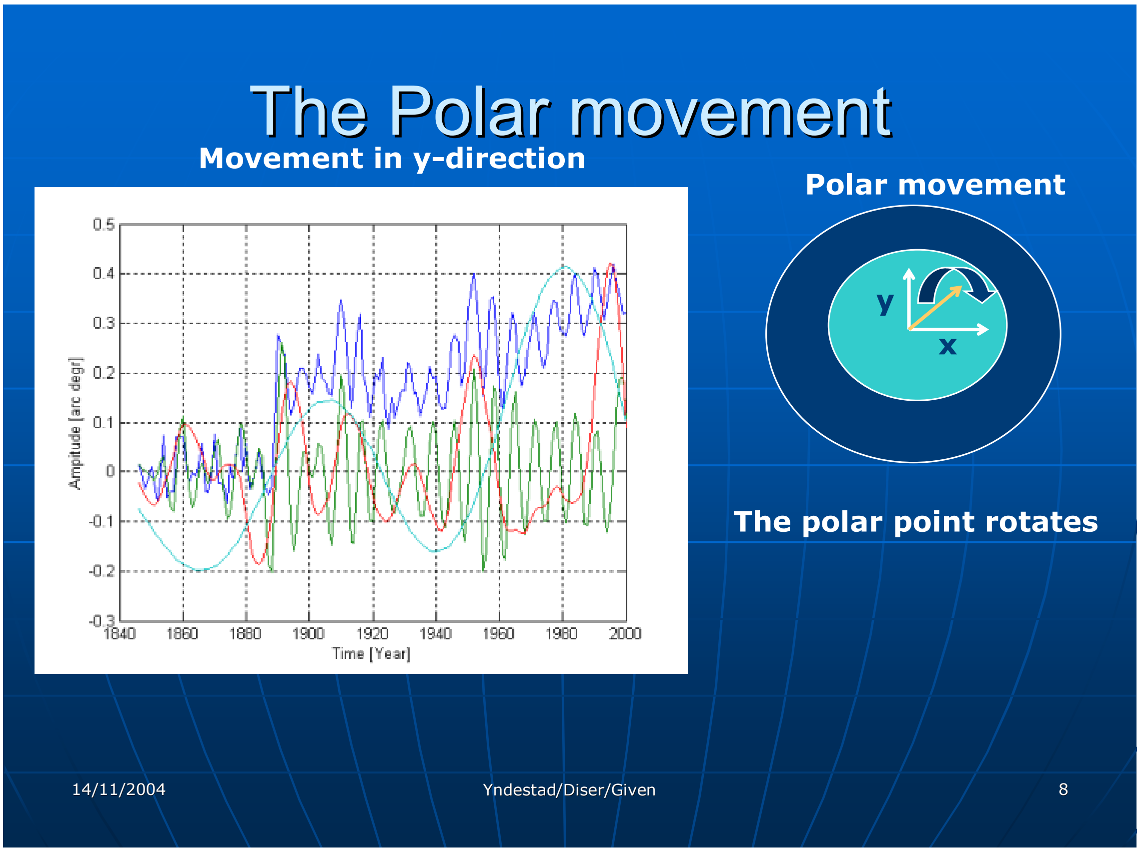
If the same thing is happening the next time, when the 672-yr moon cycle changes from a negative to a positive state.

1. We may expect a new phase-reversal at about the year 1433-672=2105.
2. The “little ice age” may start 100 years from now.

This analysis indicates that

1. Climate change is an oscillating process, controlled by external forces
2. Large changes are associated with phase-reversals in climate oscillations.

The Polar movement



Dynamics from polar movement
The importance of long-term dynamics is related to the size of masses.
From this point of views, it may be a good idea to study the movement of the solid Earth.

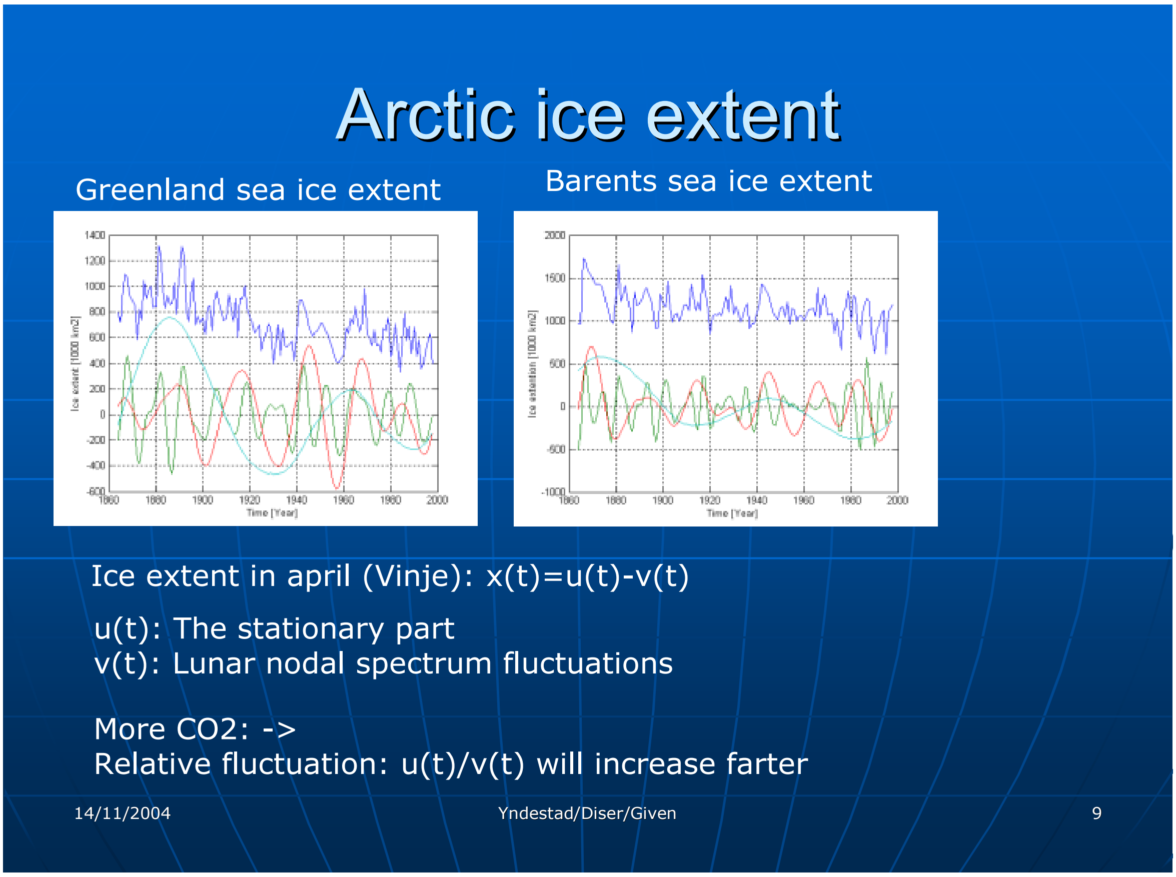
The wavelet analysis
This slide shows the result of a wavelet analysis of polar movement in y-direction.
The spectrum has dominant cycles of

1. The 1.2-yr Chandler wave
2. The 6-yr Chandler wave envelope
3. The 18.6-yr Earth notation cycle from the spinning Earth axis.
4. A 74-yr cycle, which is a new interesting cycle period

Summary

1. The Polar point is a rotating process.
2. The rotating process has a lunar nodal cycle spectrum

Arctic ice extent



The Arctic ice extent
There is a relation between the Polar movement and Arctic ice extent.
This is the time series of Arctic ice extent in April. The time series is from Vinje and covers ice extent in the Barents Sea and the Greenland Sea.

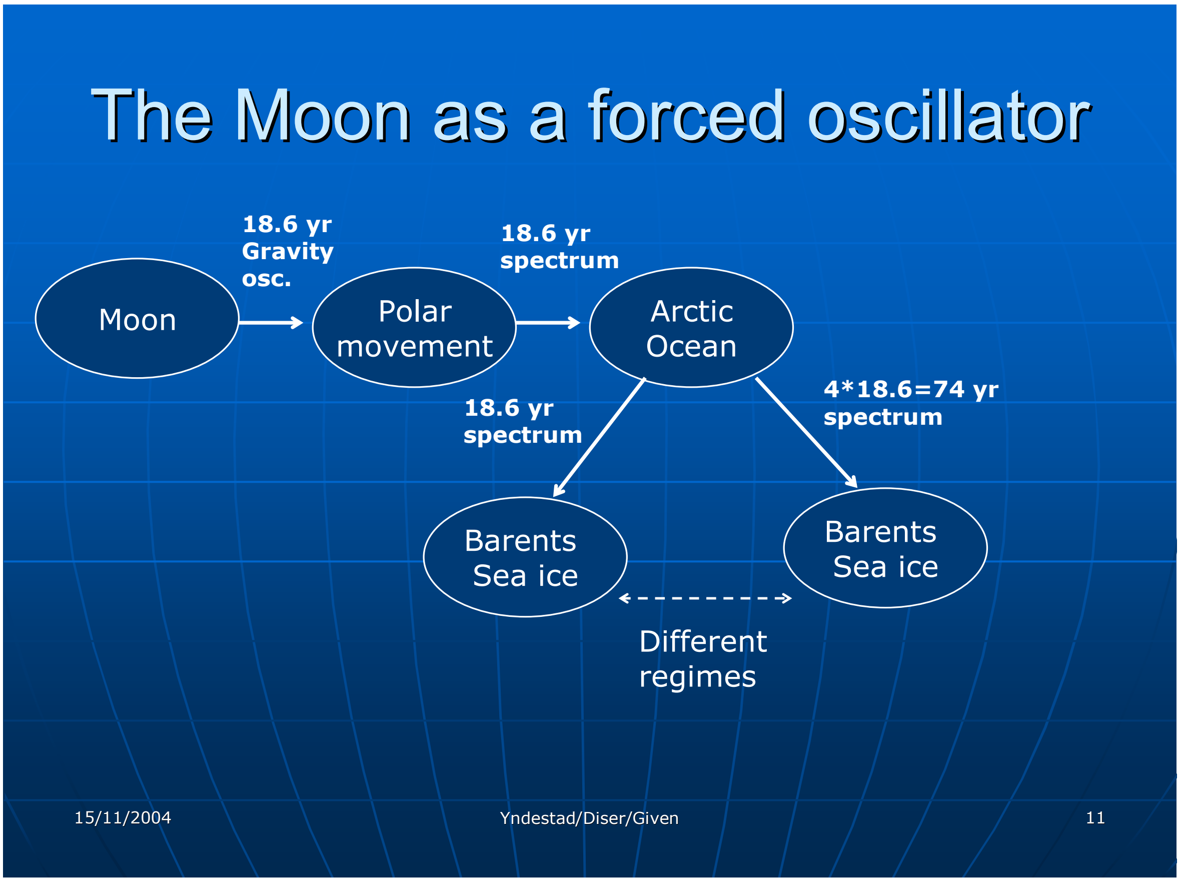
The results
The wavelet analysis shows:

1. A steady ice reduction of about 30 % from 1864 to 1997.
2. Barents Sea ice extent has the same lunar nodal cycles as identified in Polar movement cycles.
3. The lunar nodal cycles have a stationary amplitude variation.
4. Greenland Sea ice extent seems to be influences by harmonics from the 74-yr cycle

The anthropogenically-induced climate warming influence

1. It will speed up the natural process of a continuing increased warming and ice reduction the next 100 years.
2. It will speed up the natural process of a continuing increased temperature fluctuation between summer time and winter time the next 100 years.
3. It is a possibility, it may trigger an earlier climate cooling process caused by a disturbance in the circulation deep water.

The Moon as a forced oscillator



A concept model:
The cycle times and cycle phase in ice extent may be explained by a possible chain of events.

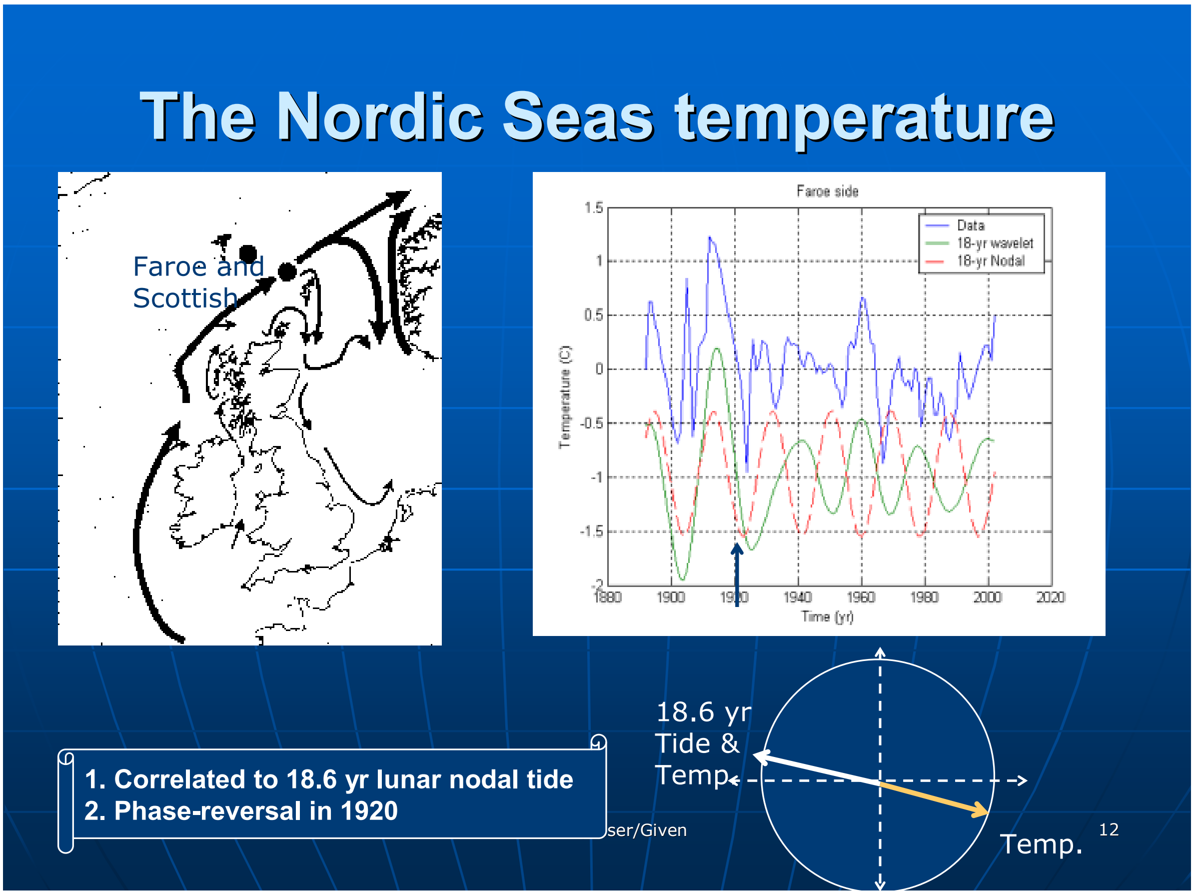
The chain of events
The wavelet spectrum indicates a possible chain of events

1. The oscillating gravity cases an oscillating Polar movement
2. The spectrum of the oscillating Polar movement response influences the water circulation in the Arctic Ocean. "The wine glass theory".
3. The oscillating Arctic Ocean introduces an 18.6-yr spectrum of ice extent in the Barents Sea
4. The outflow of cold water from the Arctic Ocean to the Greenland Sea seems to have a harmonic spectrum from the polar movement cycle of about 4*18.6=74 years.
5. A time series study of ice extent in the Iceland Sea, supports the theory that Iceland Sea temperature spectrum is influences by the temperature spectrum from the Greenland Sea.
6. Different cycle periods and cycle phase in the Greenland Sea and the Barents Sea, introduces different ecological dynamics.

What is the influence on the Nordic Seas?

1. The Barents Sea and the Greenland Sea will have different eco dynamic systems.
2. In the Greenland Sea the dynamics will be slower and different timing or phase in the cycles.
3. The Iceland Sea, north of Iceland, will have dynamics similar to the Greenland Sea.

The Nordic Seas temperature



This time series
The Nordic Seas has an important inflow in the shelf between Faroe and Scotland.

The results
This slide shows that

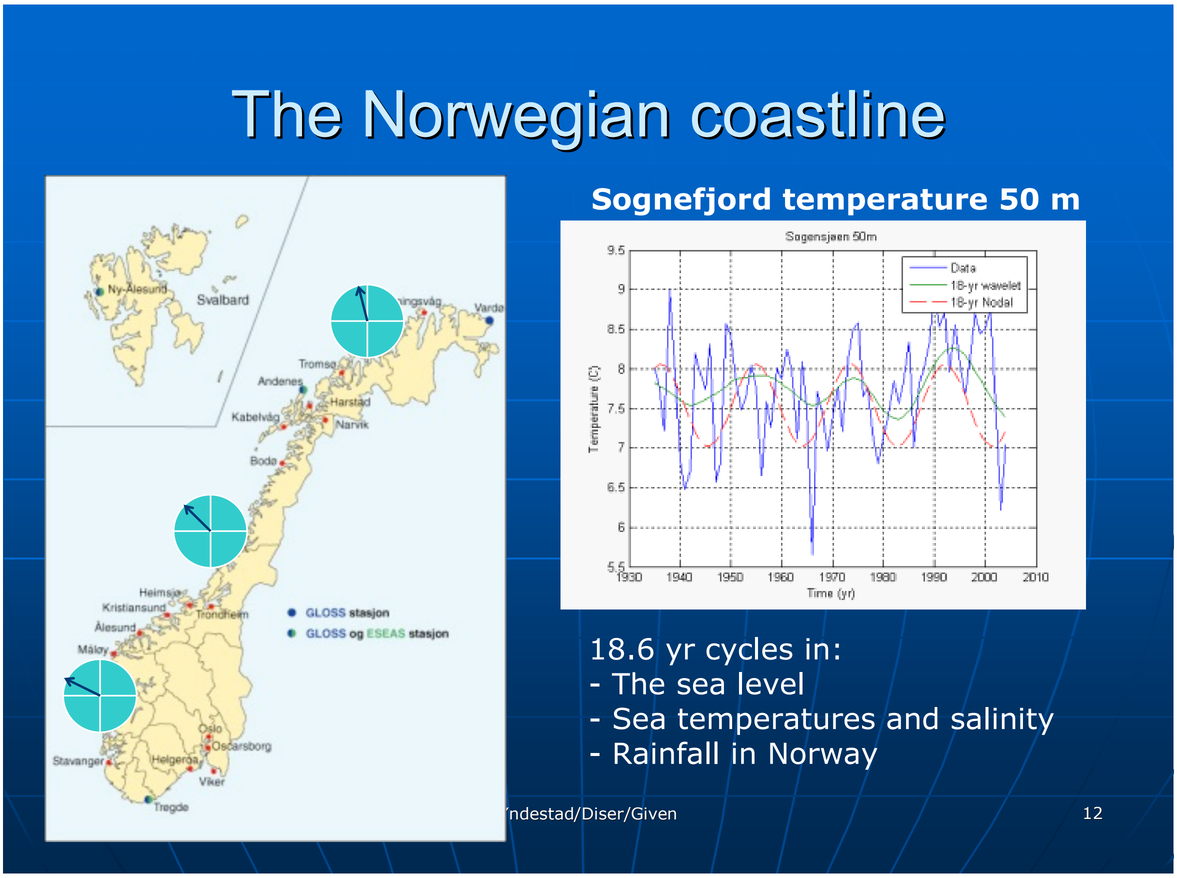
1. The time series has dominant 18-yr cycle periods related to the 18.6-yr lunar nodal tide.
2. The cycle has a 180 degrees phase-reversal at about 1920.
   The same time the 74-yr cycle of Arctic ice extent had a maximum.
   The same time the 74-yr cycle in Polar motion shifted from positive to a negative state.

More analysis shows that:

1. The time series from the Scottish side has the same 18.6-yr cycle
2. The 18.6-yr cycle in the Kola time series was delayed by about 3 years
3. The salinity time series had the same cycle, but more unstable
4. All-time series had a phase-reversal at about 1920

The phase-reversal problem
The phase-reversal is an important discovery. A phase-reversal represents a regime shifts in dynamic. This regime shift will cause a miss-match between the oscillation sea temperature and the oscillating biomasses. The cause of this phase-reversal is unclear. The linking to the Polar movements indicates an external gravity force from the Moon.

The Norwegian coastline

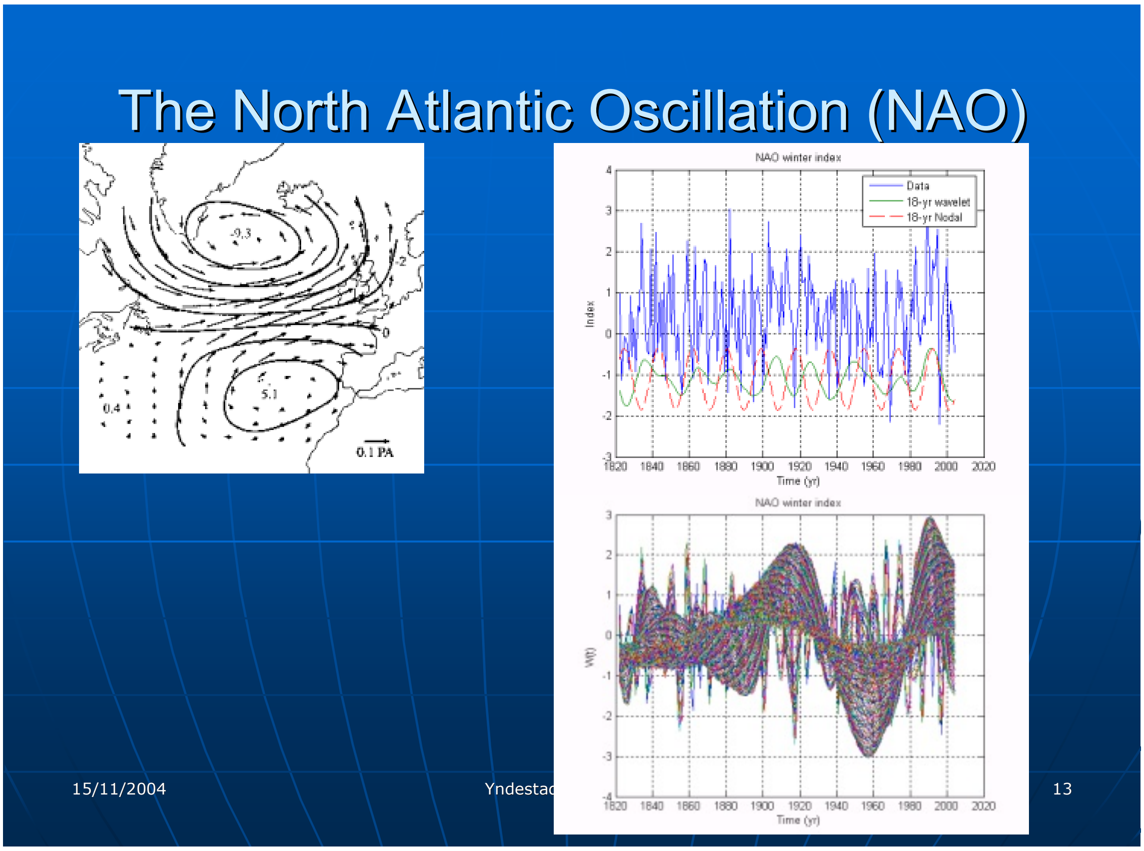


The time series
The identified 18-yr lunar nodal cycles at the Faroe Scotland channel are identified at the Norwegian coastline. My late unpublished investigation shows that

1. The 18.6-yr lunar nodal tide is identified in all sea level time series in the Norwegian coastline from Oslo to Vardø. The lunar nodal tide has a phase delay of 3 years between Møre and Finnmark.
2. IMR in Bergen has monitored time series of temperature and salinity on the Norwegian coastline. The 18.6-yr cycle is identified in all time series
3. The same 18 cycle is identified in time series of rainfall in Norway

The influence on the Nordic Seas
1. The 18.6-yr lunar nodal tide influences the eco system in the Norwegian Sea on the Norwegian coastline.
2. There is a phase delay of about 3 years between Møre and Lofoten may influence the dynamics of biomass growth.
3. A slowly change of the phase will influence the timing, spawning places and optimal recruitment. This may explain why the spawning of herring has moved north,

The North Atlantic Oscillation (NAO)



The North Atlantic Oscillation (NAO)
The North Atlantic Oscillation (NAO) represents the air pressure difference between Iceland and the Azores outside Portugal.

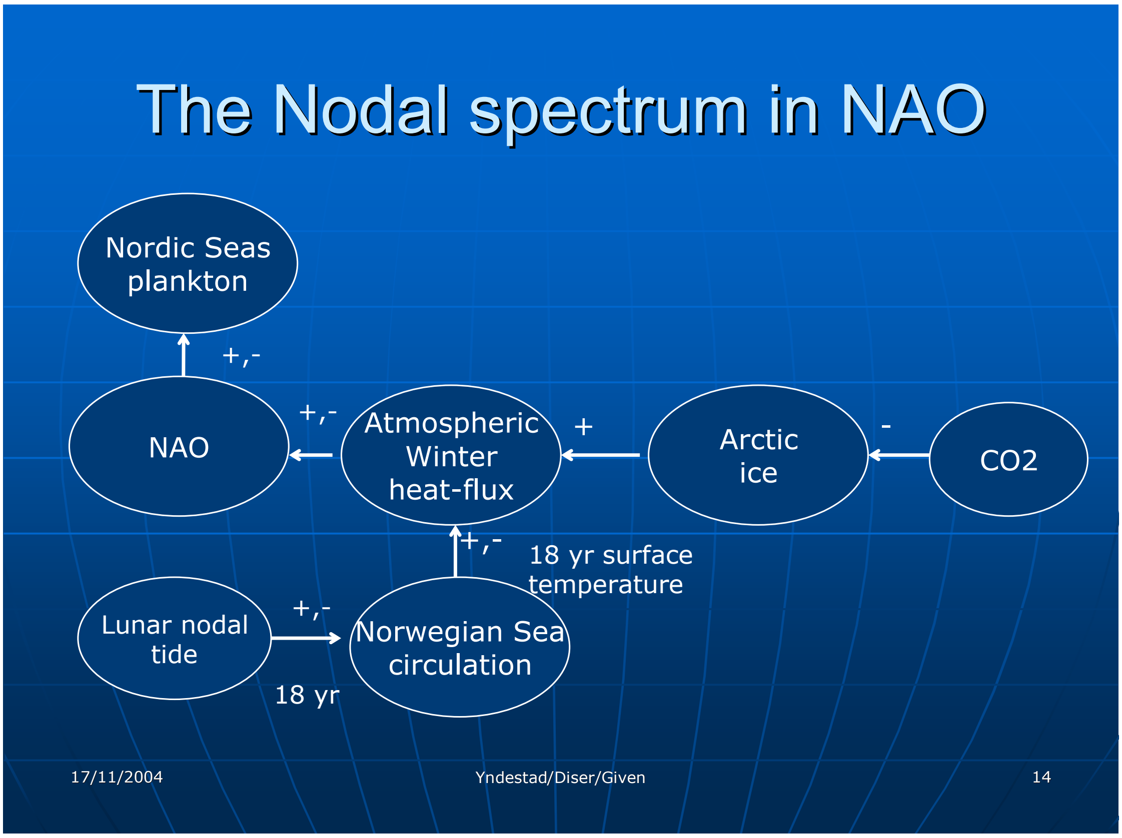
The slide shows the time series from 1822 to 2004, the wavelet spectrum, the identified 18.6-yr lunar nodal cycle and the lunar nodal cycle as a reference.

The results:
The wavelet analysis shows that
1. The NAO has cycles from the lunar nodal spectrum
2. The phase of the 18.6-yr cycle follows the 18.6-yr cycle in the Barents Sea
3. The dominant 74-yr cycle has an increasing amplitude in the total time series
4. The phase of the 74-yr cycle follows the phase of the mean Arctic ice extent in the Barents Sea and the Greenland Sea.
5. The 74-yr cycle introduces a phase-reversal at the minimum at about 1890 and 1960. This means this cycle introduces regime-shifts in climate

The influence on the Nordic Seas
The 18.6-yr spectrum in the NAO winter index indicates that:
1. The Atmospheric forcing on the eco system (wind, pressure, light, heat-flux, fresh water), has about the same temporary spectrum as the Oceanographic forcing by temperature and salinity.

2. Atmospheric force and tide force have the same direction in the Barents Sea This explains the similarities between “The wind theory” and “The tide-theory” Atlantic inflow to the Barents Sea.
3. Atmospheric force and tide force have different phase in the south Norwegian Sea. This may introduce a more non-correlated fluctuations in biomass fluctuations.

The Nodal spectrum in NAO



The lunar nodal spectrum may be explained by the following change of causes:

The ocean modulation

1. The lunar nodal tide introduces a long-term vertical circulation of water.
2. The vertical circulation influences the surface temperature
3. Oscillating surface temperature will introduce an oscillating transport of heat-flux in the winter to the atmosphere.
4. The 18.6-yr cycle phase indicates a NAO influence from the Norwegian Sea and Arctic ice.

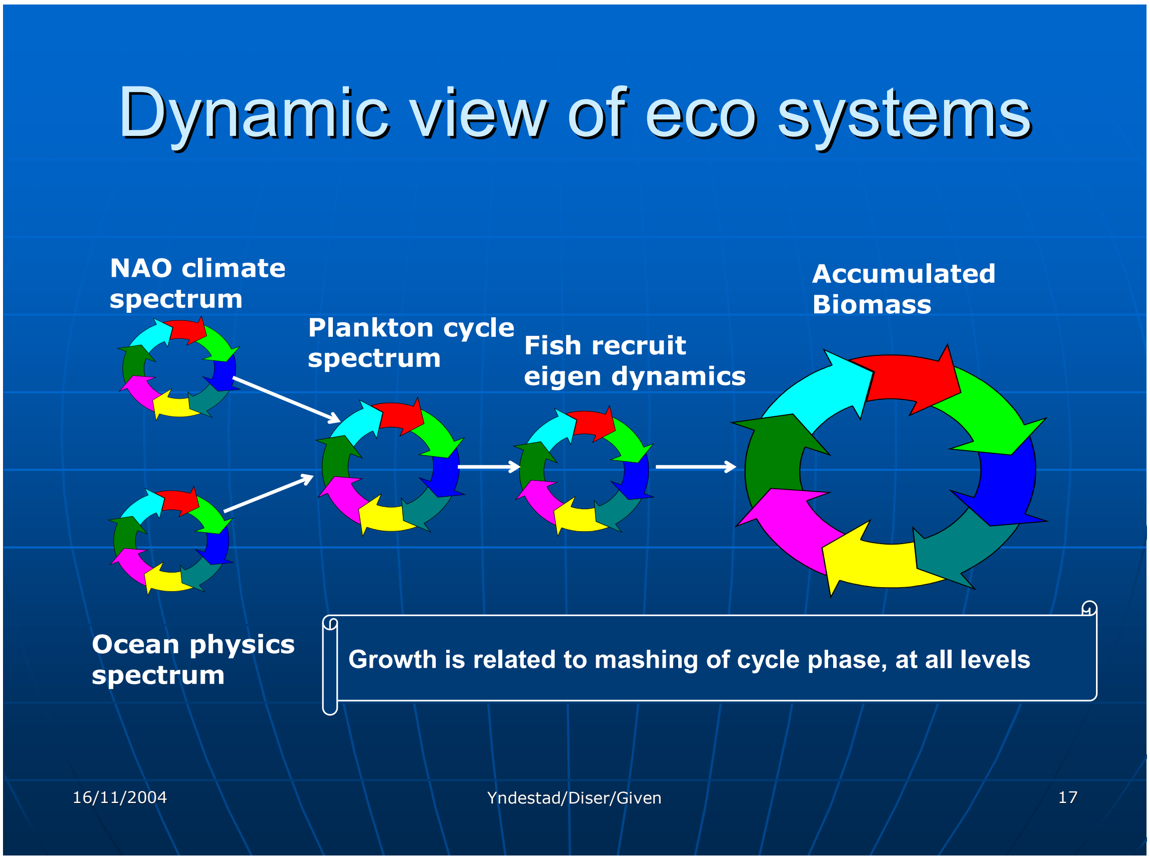
The Arctic ice modulation

1. The Arctic ice extent is an isolation between the air and sea temperature and thus influences the NAO winter index
2. Long-term cycles of Arctic ice extent may introduce long-term cycles in the NAO winter index.

The influence from climate change

1. Stronger fluctuation between Arctic summer temperature and winter temperature.
2. Stronger fluctuations in the NAO winter index
3. Stronger fluctuations in the weather condition the Nordic Seas

Dynamic view of eco systems



The dynamic model

This is a simple model of a dynamic eco system.

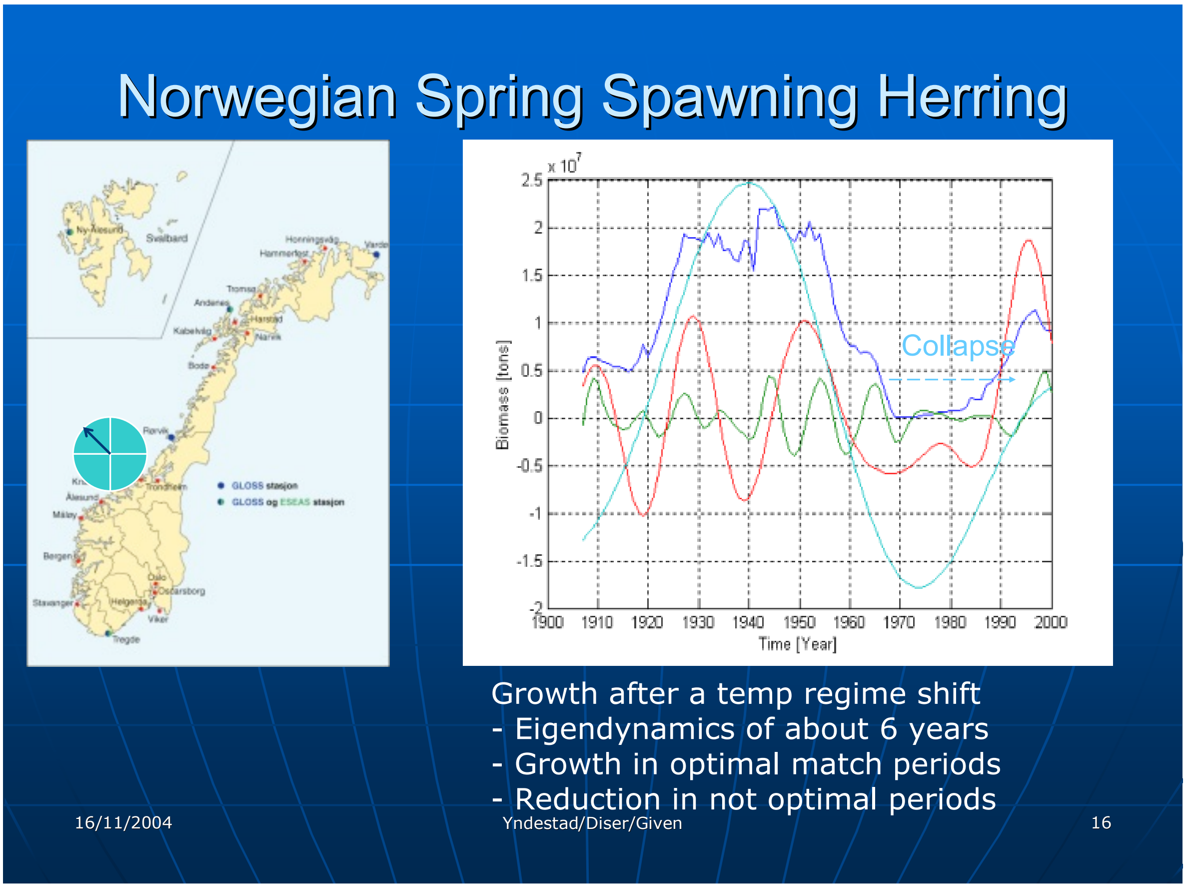
1. The climate dynamic oscillation represents the forced oscillation input to the eco system.
2. The long-term growth is related to matching of cycle phase, at all level in the food chain.

Potential influence from climate change:

1. The oscillation amplitude increases:
   The amplitude of the biomasses in the eco system increases
   In other words, more long-term biomass fluctuations
2. Changes in the spectrum phase relation
   Changes in the biomass long-term growth
3. The climate spectrum changes:
   Then we have a regime shift and a biomass “collapse”.
   It takes time to synchronic biomass cycle to the new spectrum.

In other words, it is not for sure that there will be introduces new species.

Norwegian Spring Spawning herring



The time series
This time series represents the biomass of Norwegian spring spawning herring in the period 1908 to 2000. Herring has a spawn on the Norwegian coastline and I think this time series illustrates a fundamental property of long-term biomass growth in the Nordic Seas and the Barents Sea.

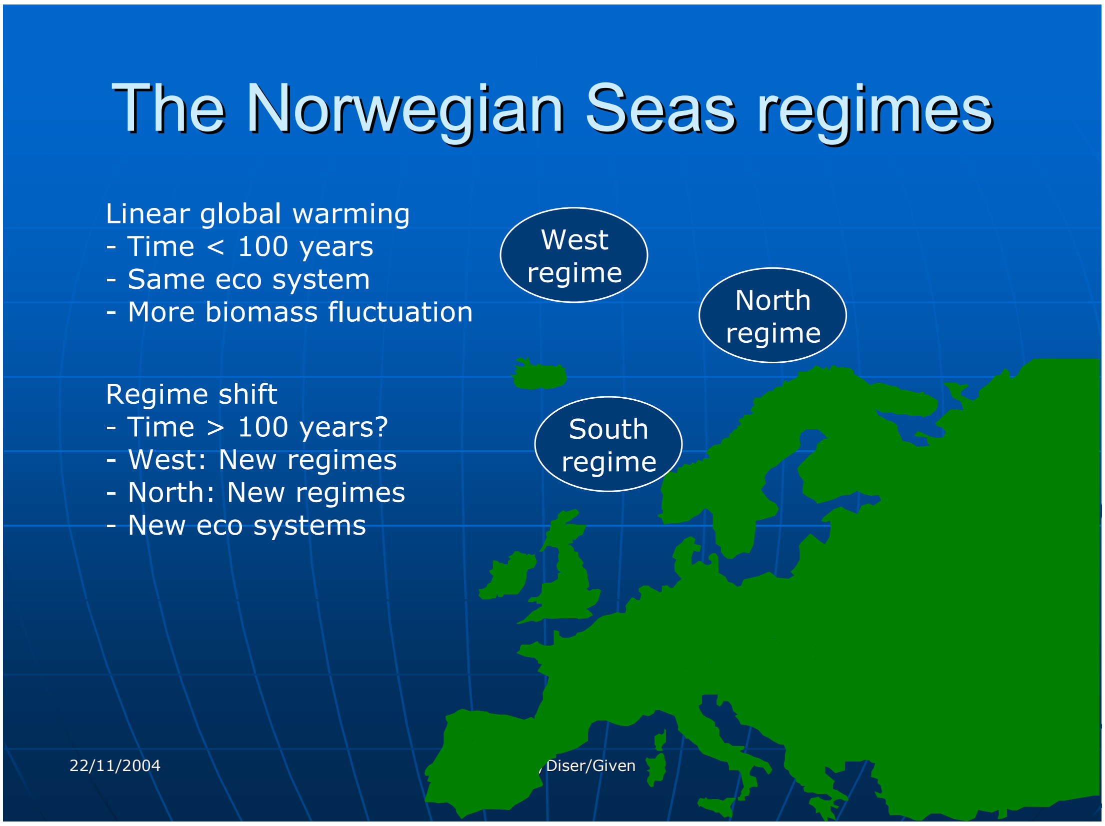
Biomass growth cycles

1. The growth came after the temperature cycle phase-reversal at about 1918
2. The biomass has an eigen-dynamics of about 6 years. The same period at the 6-yr tidal cycle in the Barents Sea.
3. If a growth in a period of 3 generation of optimal recruitment
4. If a biomass reduction in periods of miss match in recruitment

Influence from climate change

1. Herring is dependent the phase relation between biomass eigen-dynamics and the cycles in the lunar tide spectrum.
2. Increased climate fluctuations will influence the timing and optimal spawning place.

The Norwegian Seas regimes



Final summary
So, what is the impact from increased CO2 and increased Arctic temperature?

This analysis indicated that the Nordic Sea have 3 different eco system regimes. Causes by 3 different climate spectra.

1. The South eco system regime:
   Controlled by the 18.6 spectrum from tides, and a delayed NAO spectrum
2. The North eco system regime:
   Controlled by the 18.6-yr spectrum from tides, Polar movement and the NAO
3. The Was eco system regime:
   Controlled by the 24-yr spectrum from the Arctic Ocean water circulation

The anthropogenically-induced climate warming
The linear model
1. Will change the amplitude and not the spectrum in the all regimes
2. This will lead to more fluctuations in the biomasses.
   More biomasses in the good periods
   Less biomasses in bad periods.
3. The biomass structure will be the same.
   New spices are dependent on the eigen-dynamics

The external forces

1. Changes in the forced lunar nodal spectrum may cause a new spectrum in tides and Polar movement.
2. A new lunar nodal spectrum will cause regime shifts and biomass collapse in all eco systems.