Freshwater outflow of the Baltic Sea and transport in the Norwegian Current: A statistical correlation analysis based on a numerical experiment

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Baltex Conference, Öland, June 10th 2013



Outline



- What is the purpose?
- What is the method
- ⁽³⁾ Reconstruction of the BS outflow
- *Reconstruction of the NCC freshwater transport*
 - Only based on wind data
 - Based on wind & salinity data

6 Conclusion

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Purpose

Outline



What is the purpose?

- (3) Reconstruction of the BS outflow

Only based on wind data

• Based on wind & salinity data

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Purpose

6.00 8.00



• The BS freshwater outflow is poorly described in many climate & operational models for which the BS is considered as a river

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Hordoir et al

Freshwater outflow of the BS, transport in the NCC

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- The NCC freshwater transport is also important for Arctic freshwater content

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- The BS freshwater outflow is poorly described in many climate & operational models for which the BS is considered as a river
- The NCC freshwater transport is also important for Arctic freshwater content
- Is there an easy way to estimate their variability ?

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Framework



• The BS freshwater outflow has little correlation with runoff in the BS

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Hordoir et al. Freshwater outflow of the BS, transport in the NCC

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- The BS freshwater outflow has little correlation with runoff in the BS
- The BS freshwater outflow is mostly correlated with mean zonal wind variability *Hordoir & Meier*, *JGR*, 2009

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Framework

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- The BS freshwater outflow has little correlation with runoff in the BS
- The BS freshwater outflow is mostly correlated with mean zonal wind variability *Hordoir & Meier*, *JGR*, 2009
- So there must be a way to estimate this flow based only on wind data, and perhaps even estimate that of the NCC

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Outline



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3 Reconstruction of the BS outflow

Reconstruction of the NCC freshwater transport
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BaltiX - Domain & Forcing



• Ocean modelling configuration based on the NEMO ocean engine

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BaltiX - Domain & Forcing



• Ocean modelling configuration based on the NEMO ocean engine

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• NEMO 3.3.1 for the time being

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BaltiX - Domain & Forcing



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- Geographical grid, approx. 2nm resolution, 56 vertical levels, 3m resolution at the surface

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BaltiX - Domain & Forcing



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- RCA3 re-analysis (Zoom on Europe with ERA40 at the OBCs), 3 hour frequency, 1961-2009
- 31 rivers with inter-annual variability in the Baltic Sea, climatology in the North Sea with salinity of 10⁻³ PSU

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BaltiX - Options



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• Fully non-linear free surface, $k - \epsilon$ vertical turbulence

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BaltiX - Options



• Fully non-linear free surface, $k - \epsilon$ vertical turbulence

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 Isopycnal diffusion, BBL parameterisation, partial steps, LIM3

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BaltiX - Options



- Fully non-linear free surface, $k \epsilon$ vertical turbulence
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- TVD scheme, time step of 360s, time splitting

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BaltiX - Options



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• Validation done on SSH, thermo-haline structure

BaltiX - Diagnostics



• Monitoring of the volumic/salt fluxes at the BS exit and along the Norwegian coast

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BaltiX - Diagnostics



- Monitoring of the volumic/salt fluxes at the BS exit and along the Norwegian coast
- Monitoring of the wind along the Norwegian coast, in Skaggerak, Kattegat and the BS

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BaltiX - Diagnostics



- Monitoring of the volumic/salt fluxes at the BS exit and along the Norwegian coast
- Monitoring of the wind along the Norwegian coast, in Skaggerak, Kattegat and the BS

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• Monitoring of SSS along the Norwegian coast

Outline



What is the method

3 Reconstruction of the BS outflow

Reconstruction of the NCC freshwater transport

- Only based on wind data
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BS outflow reconstruction

$$\begin{aligned} Fr_{Baltic}(t) &= \alpha_0 \\ &+ \alpha_{Baltic_1} U_{Baltic}(t - \tau_{Baltic_1}) + \alpha_{Baltic_2} U_{Baltic}(t - \tau_{Baltic_2}) \\ &+ \alpha_{Kattgt_1} U_{Kattgt}(t - \tau_{Kattgt_1}) + \alpha_{Kattgt_2} U_{Kattgt}(t - \tau_{Kattgt_2})(1) \end{aligned}$$

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• A simple regression analysis allows to find the proper delays, and the coefficients. The correlation reaches 70% using 2-daily averaged data, but too low variability (33683 $m^3.s^{-1}$ for reconstruction against 48033 $m^3.s^{-1}$ for measured signal)

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- A simple regression analysis allows to find the proper delays, and the coefficients. The correlation reaches 70% using 2-daily averaged data, but too low variability (33683 $m^3.s^{-1}$ for reconstruction against 48033 $m^3.s^{-1}$ for measured signal)
- Using monthly mean data provides a correlation of 80% and similar variability

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Only based on wind data Based on wind & salinity data

Outline



2 What is the method

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$$Fr_{Norwg}(t) = \alpha_{0} + \alpha_{Baltic_{1}} U_{Baltic}(t - \tau_{Baltic_{1}}) + \alpha_{Kattgt_{1}} U_{Kattgt}(t - \tau_{Kattgt_{1}}) + \alpha_{Norweg_{1}} U_{Norweg}(t - \tau_{Norweg_{1}}) + \alpha_{Norweg_{2}} V_{Norweg}(t - \tau_{Norweg_{2}})$$
(2)

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Only based on wind data Based on wind & salinity data



• Reconstruction for year 2000

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- Reconstruction for year 2000
- Only 60% of correlation, higher extremes are not well reproduced

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- Reconstruction for year 2000
- Only 60% of correlation, higher extremes are not well reproduced
- Higher extremes correspond to baroclinic transport?

Only based on wind data Based on wind \mathcal{B} salinity data



• We add a baroclinic term $\alpha_{Norweg_3}Sa_{Norweg}(t - \tau_{Norweg_3})$

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Only based on wind data Based on wind & salinity data



- We add a baroclinic term $\alpha_{Norweg_3}Sa_{Norweg}(t \tau_{Norweg_3})$
- Better correlation (70%)

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- We add a baroclinic term $\alpha_{Norweg_3}Sa_{Norweg}(t \tau_{Norweg_3})$
- Better correlation (70%)
- Higher extremes are better, but still misses variability

Only based on wind data Based on wind & salinity data



• The power provided by wind can be linearly related with the flux

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Only based on wind data Based on wind & salinity data



- The power provided by wind can be linearly related with the flux
- We add two non-linear terms

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Only based on wind data Based on wind & salinity data



- The power provided by wind can be linearly related with the flux
- We add two non-linear terms
- $P_w \propto V_{Norweg} imes V_{Norweg}$

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- The power provided by wind can be linearly related with the flux
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- $P_w \propto V_{Norweg} imes \delta
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Only based on wind data Based on wind & salinity data



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- We add two non-linear terms
- $P_w \propto V_{Norweg} imes V_{Norweg}$
- $P_w \propto V_{Norweg} imes \delta
 ho$
- Higher correlation (80%), better reproduction of extremes , a solution is the second second

Hordoir et al.

Freshwater outflow of the BS, transport in the NCC

Outline

- 1 What is the purpose ?
- 2 What is the method
- 3 Reconstruction of the BS outflow
- Reconstruction of the NCC freshwater transport
 Only based on wind data
 Record on wind % collimity data
 - \bullet Based on wind & salinity data

5 Conclusion

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• Possible to reconstruct BS freshwater outflow and NCC freshwater transport based on large scale data

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- Possible to reconstruct BS freshwater outflow and NCC freshwater transport based on large scale data
- However, NCC positive transport requires local salinity measurement (NCC is NOT a pure Kelvin wave)

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- However, NCC positive transport requires local salinity measurement (NCC is NOT a pure Kelvin wave)
- BS freshwater outflow is more influence by high frequencies (closed basin ?)
- All details in *Hordoir et al., Cont. Shelf Res., May 2013, DOI :* 10.1016/j.csr.2013.05.2006

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