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Research and challenges towards operational ecology and adaptive ecosystem management: Baltic Sea

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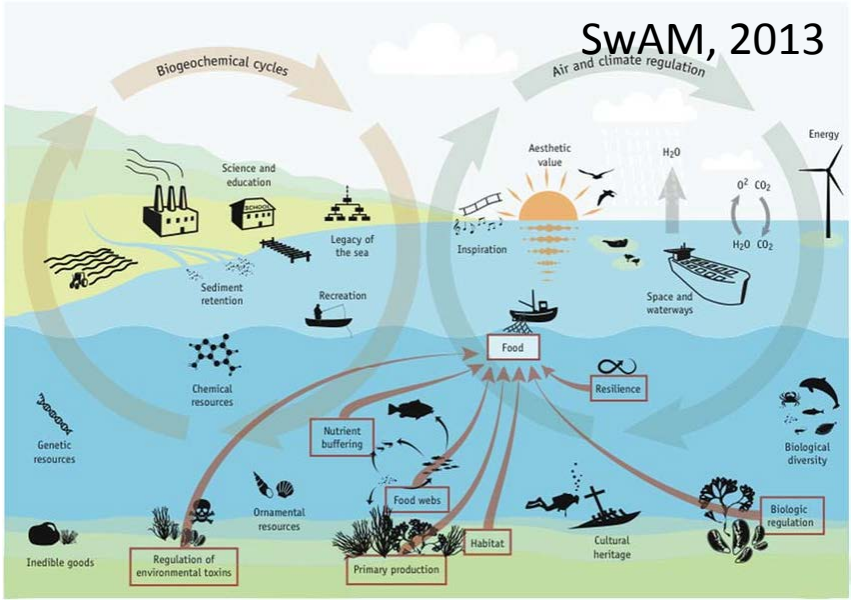
Baltic Sea situation analysis

- **Human activities**
  - Nutrient loading, fishery, shipping, tourism, aquaculture, wind farms
- **Natural variability and climate change**
  - Increased sea temperature
  - Sea level rise
  - Changes in precipitation and related river runoff and salinity
  - Changes in winds and related vertical mixing and Baltic-North Sea transport



Ecosystem change

- Response of LTL to physical and human pressures
- Eutrophication (Algae bloom, hypoxia)
- Response of HTL to LTL and pressures

Instruments for solutions

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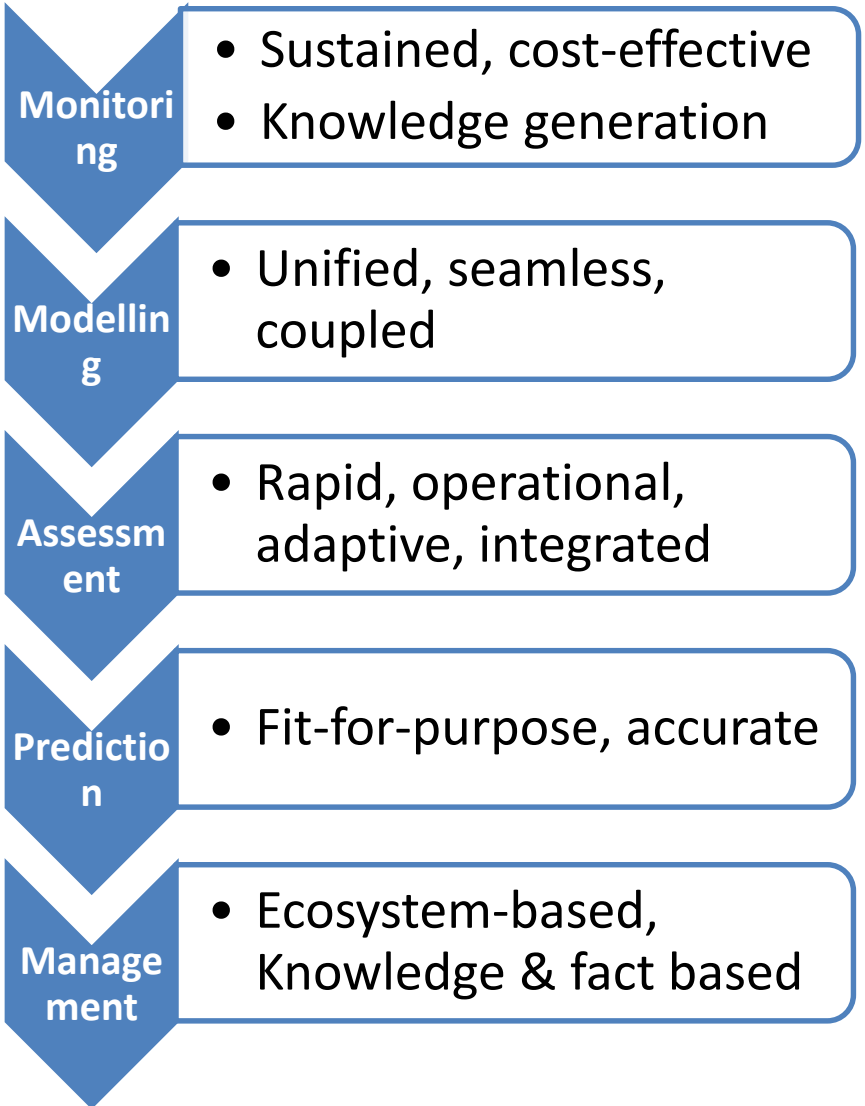
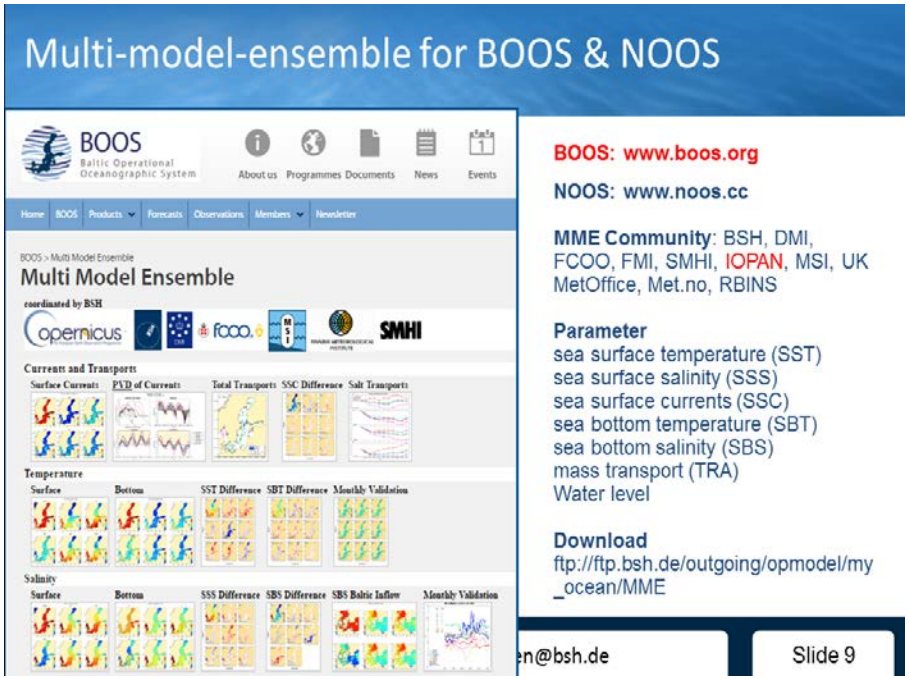


- **Policies** for member states to implement:
  - MSFD, WFD, MSP, HABITAT, CFP
- **BOOS and CMEMS (波罗的海业务海洋学系统和哥白尼海洋服务)**:
  - operational monitoring, forecast and services
- **HELCOM (波罗的海环境保护委员会)**:
  - offline monitoring, assessment, management
- **EMODnet (欧洲海洋数据网)**:
  - data collection and integration
- **BSHC/IHO (波罗的海水文委员会)**:
  - Bathymetry and maritime transport
- **VASAB(波罗的海远景战略委员会)**:
  - Marine spatial planning

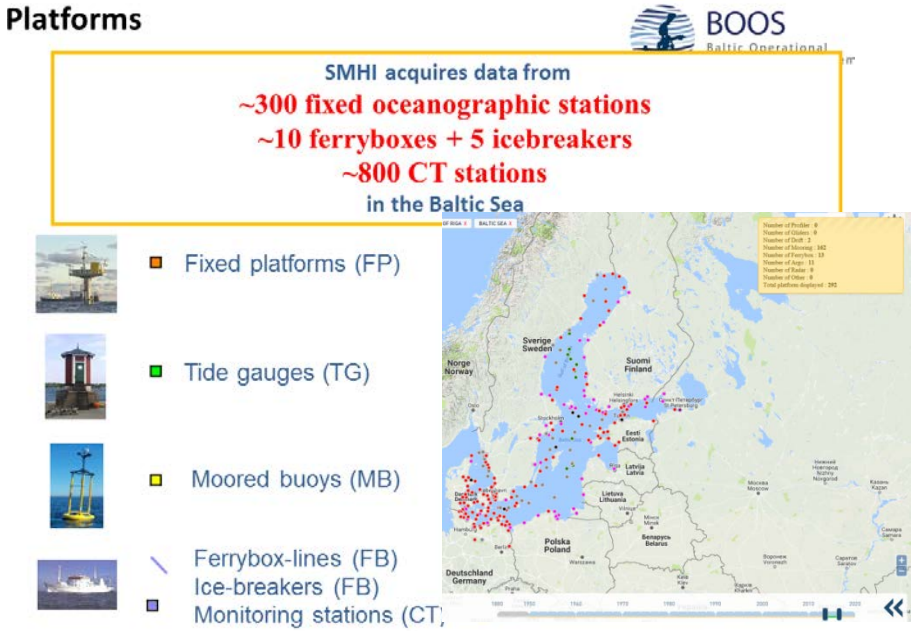
Operational services

PHY & BIO Forecasting systems :
HBM-ERGOM, NEMO-SCOBI



波罗的海-北海多模式集合预测系统

Monitoring: BOOS, Argo, gliders, ferrybox, moorings etc



波罗的海业务观测系统

Seamless modelling: Danish ocean-ice forecasting system to resolve coastal-estuary continuum

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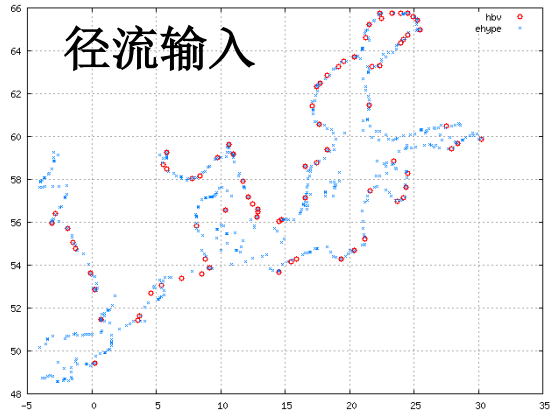
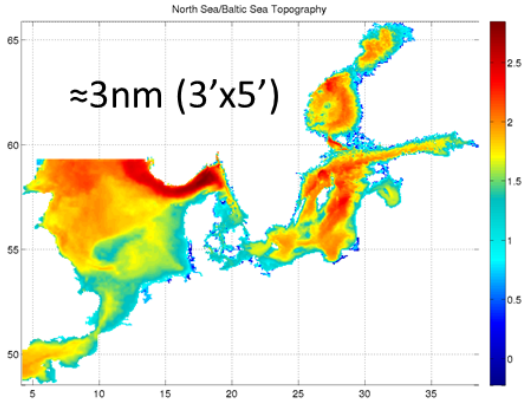
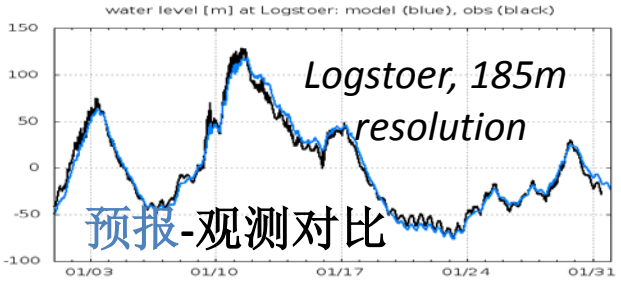
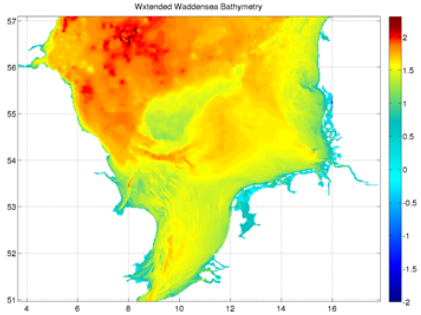


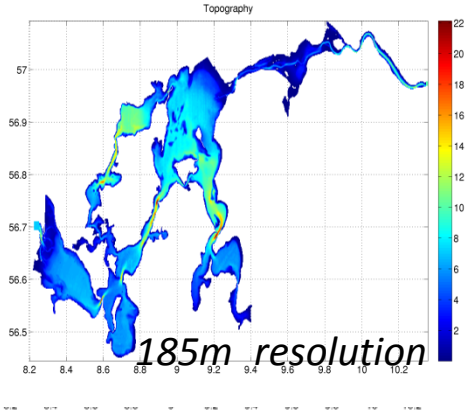




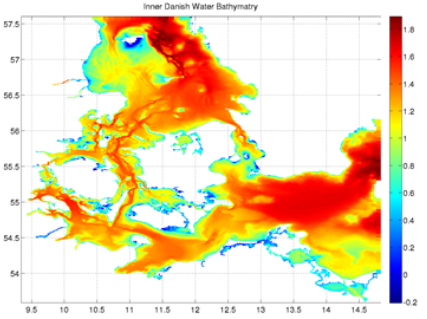
双向嵌套高分模式

≈1nm (1'x1.66')

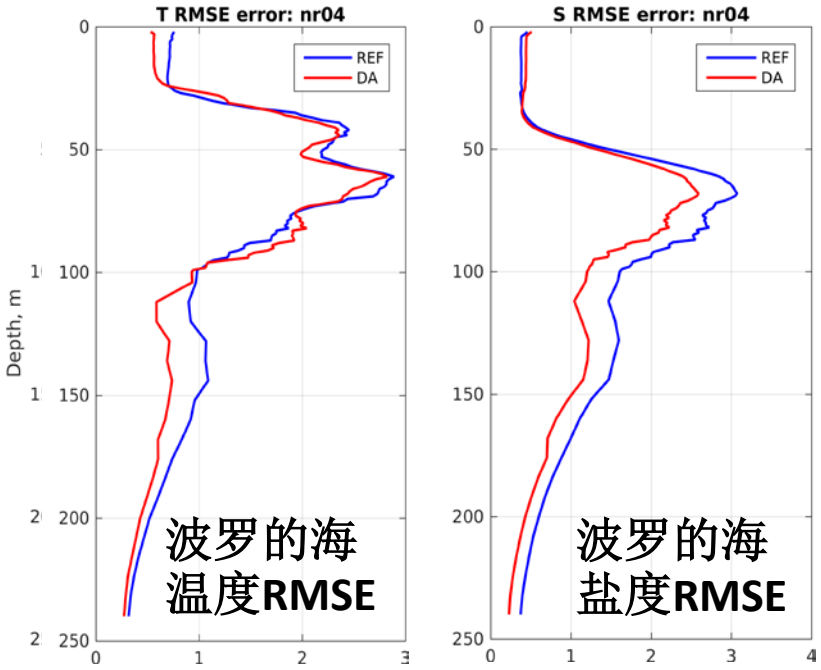




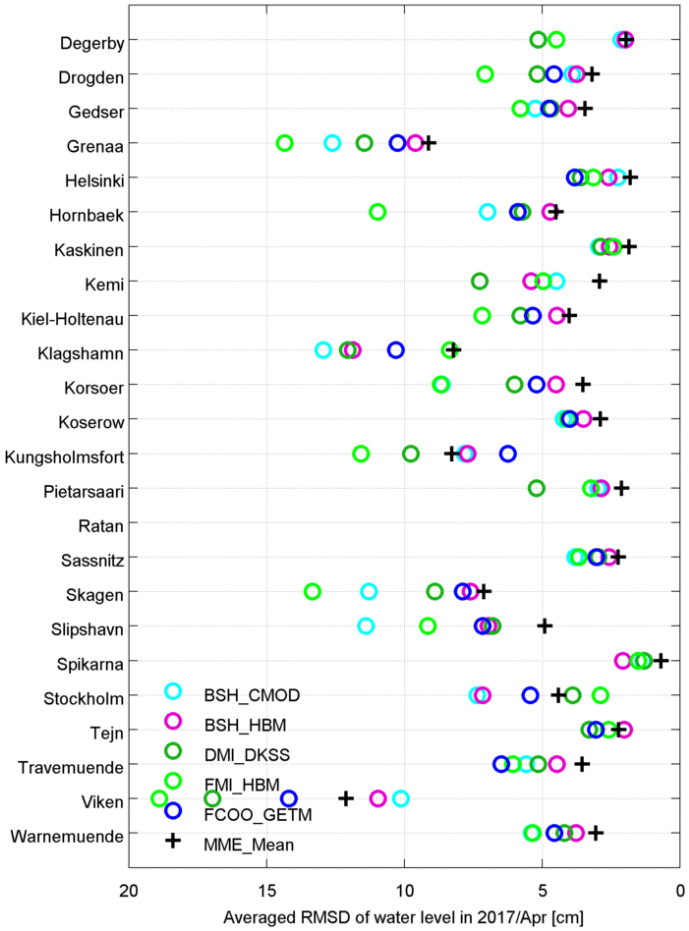
≈0.5nm (30''x50'')



Product validation

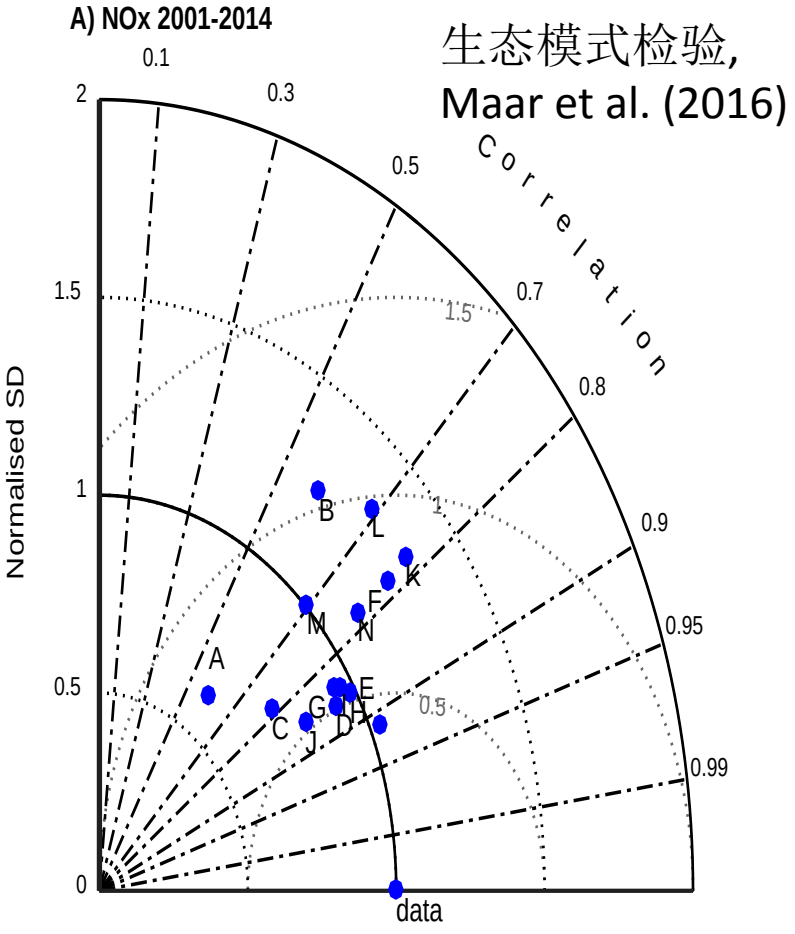


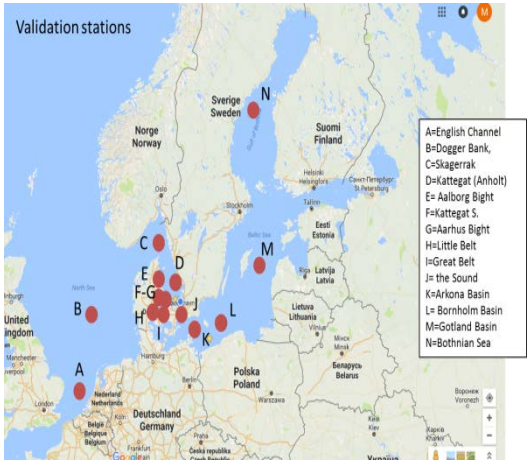
BALMFC 海浪预报, 有效波高检验, 1 海里分辨率

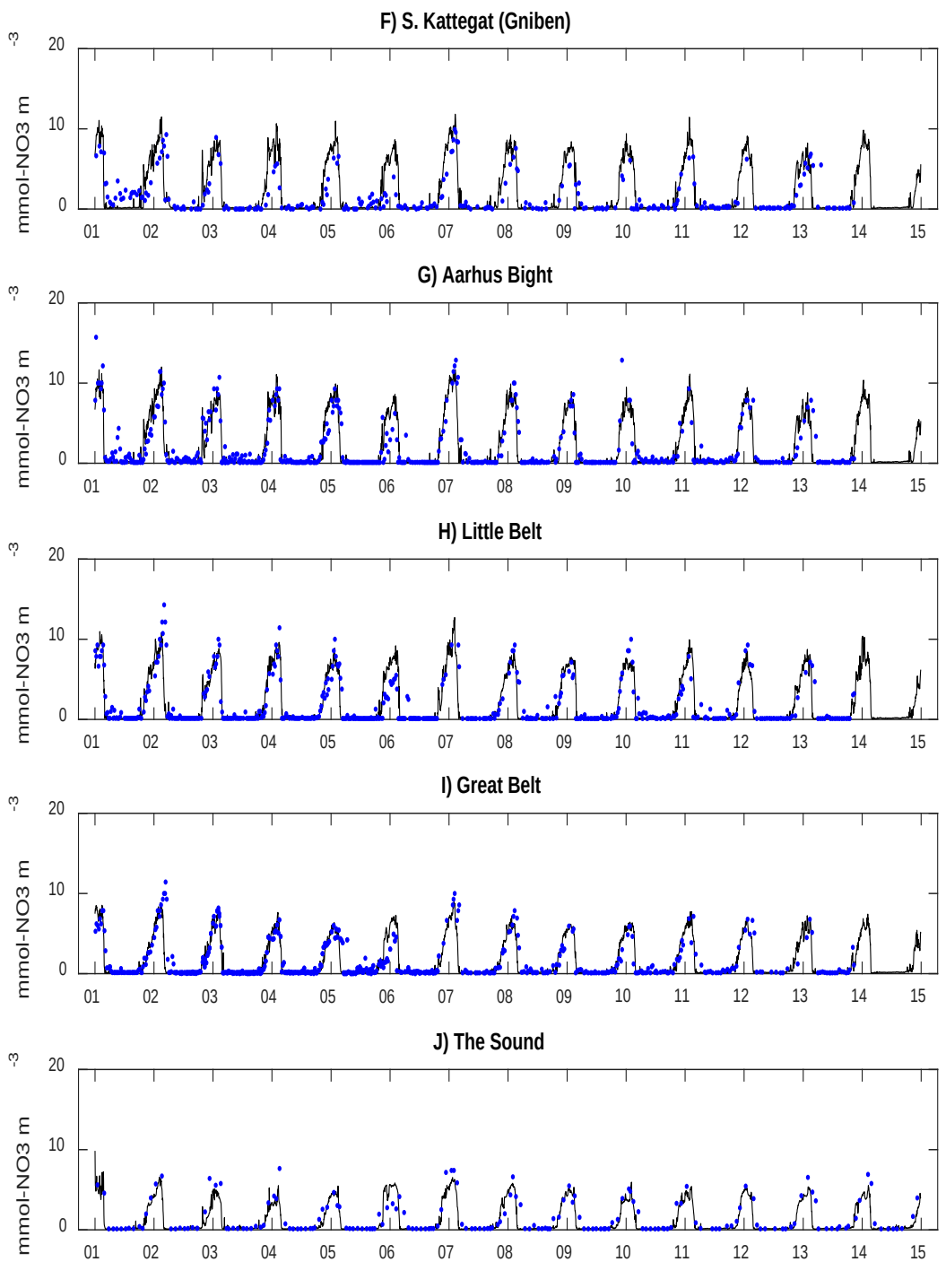


波罗的海多模式水位集合预报: 站位-RMSD (2017年4月).

生态模式检验，Maar et al. (2016)



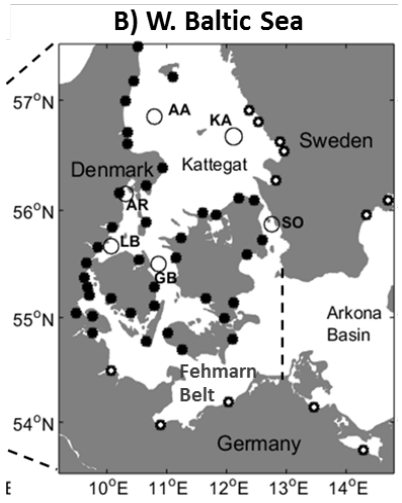


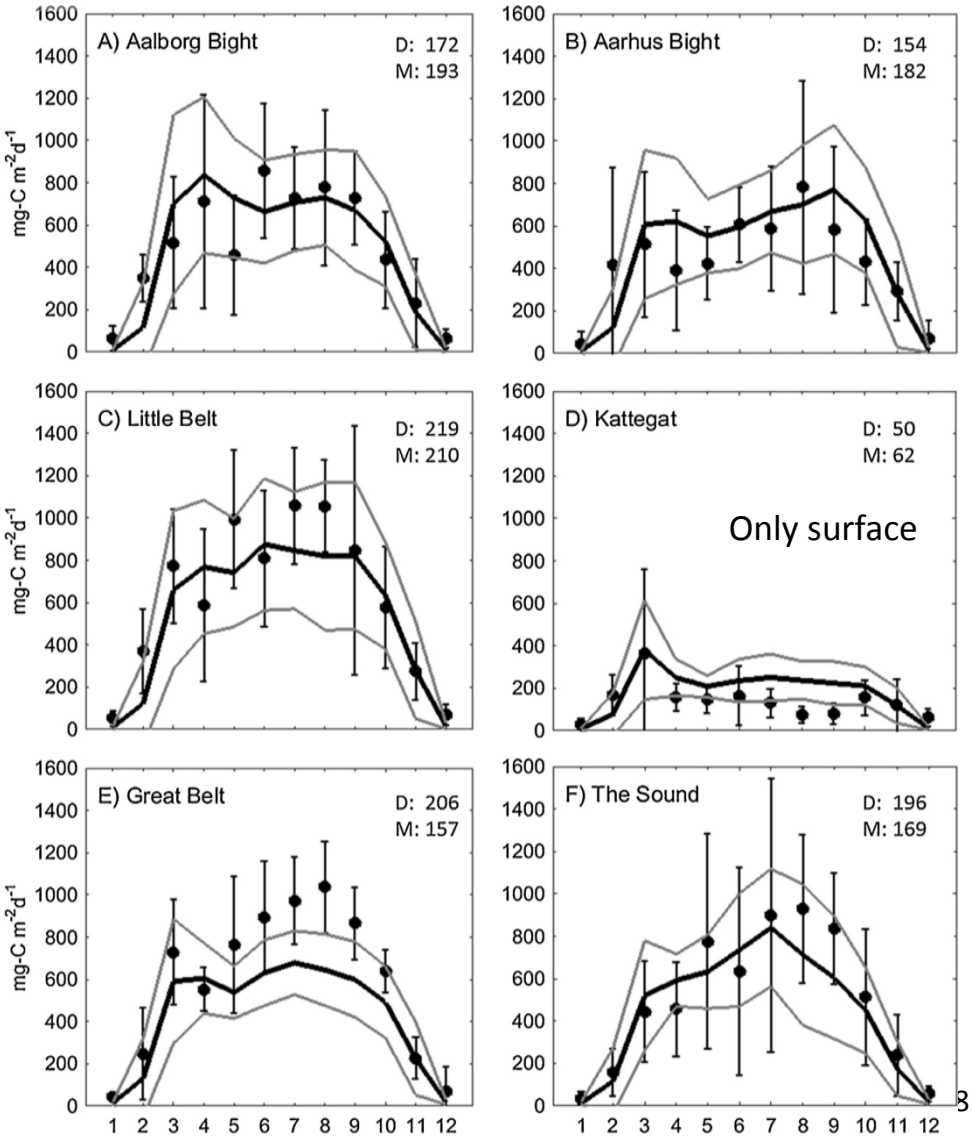


PRIMARY PRODUCTION
(MAAR ET AL, 2016; 基础生产力检验)

Monthly means 2001-2009

- Data ± SD (●)
- Model (black line)
- Model mean ±SD (grey lines)





All stations: R^2 = 0.59, PMB= 1%, nSD=0.83

Integration of online and offline observations
线上线下集成

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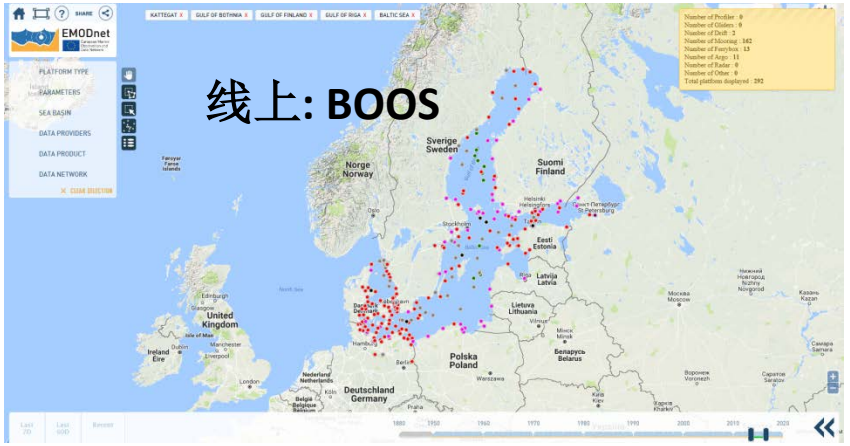
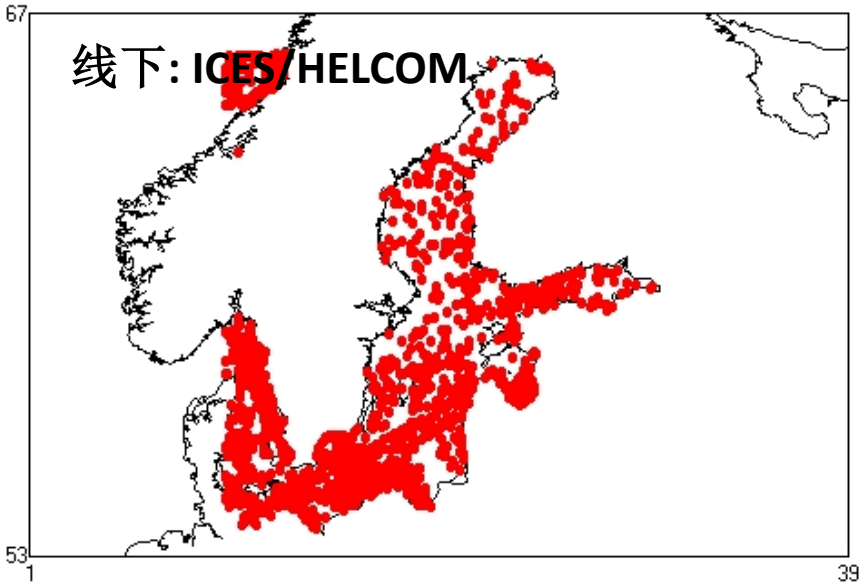
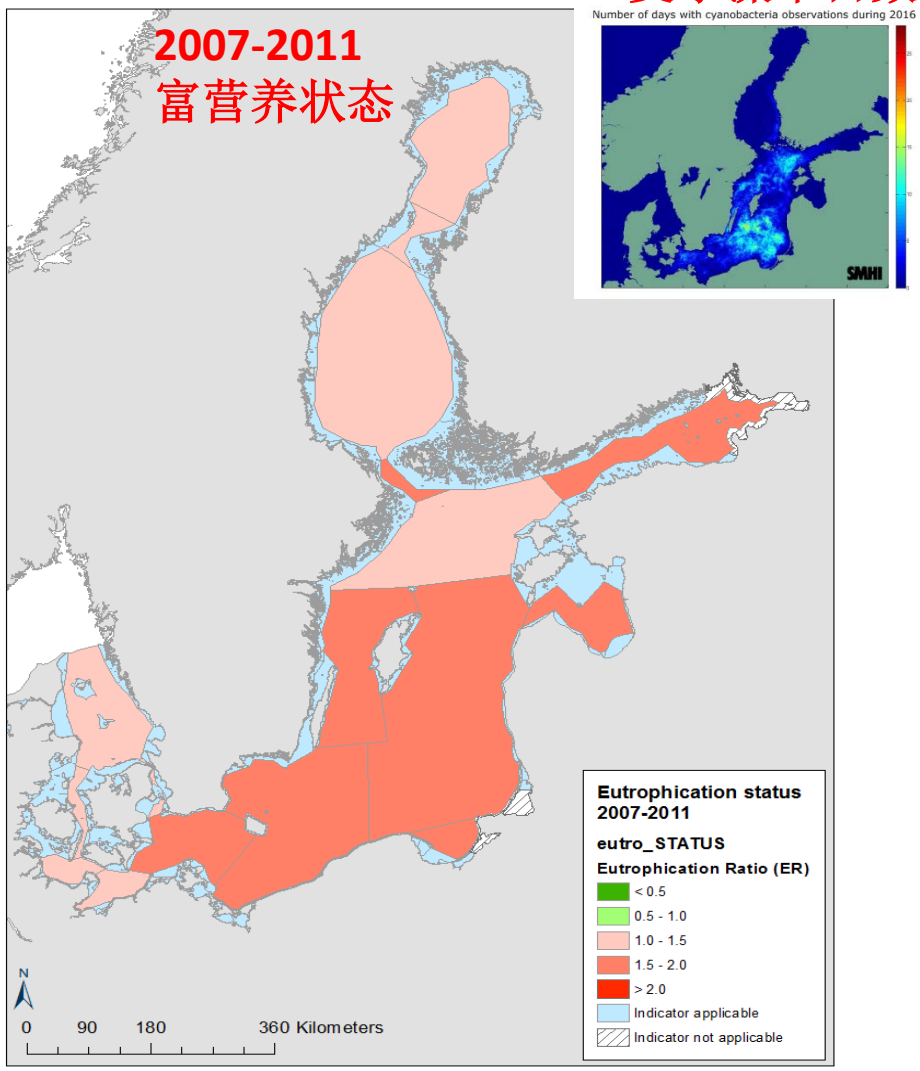
- SST:
  - More integration of satellite and BOOS (esp. Ferrybox) observations
- T/S:
  - More integration of BOOS (mainly coastal) and Helcom/ICES (mainly offshore) observations
  - NRT delivery of R/V data
  - Adding adaptive observations eg from gliders
- Sea level:
  - More integration of satellite and BOOS tidal gauge data
- Offshore wind profile & currents:
  - Not sufficiently monitored and shared





HELCOM eutrophication assessment

- **5 year assessment** (in-situ data only):
  - 2001-2006
  - 2007-2011
  - 2012-2016 (in preparation)
- **Yearly fact sheets** (satellite data used)
  - Öberg, J., 2016. Cyanobacteria blooms in the Baltic Sea. HELCOM Baltic Sea Environment Fact Sheets 2016. Online.



CMEMS Ocean State Report 2016: Baltic Sea inflow, Eutrophication, hypoxia, low sea level event (BAL MFC, CNR)

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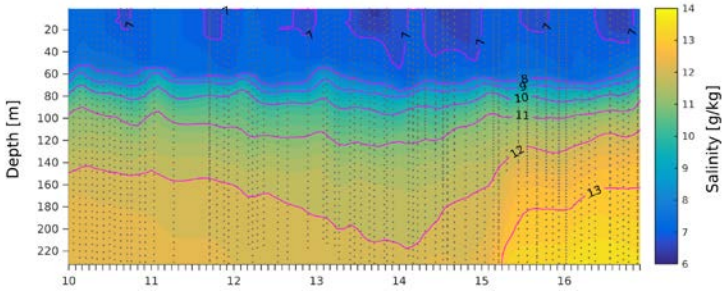
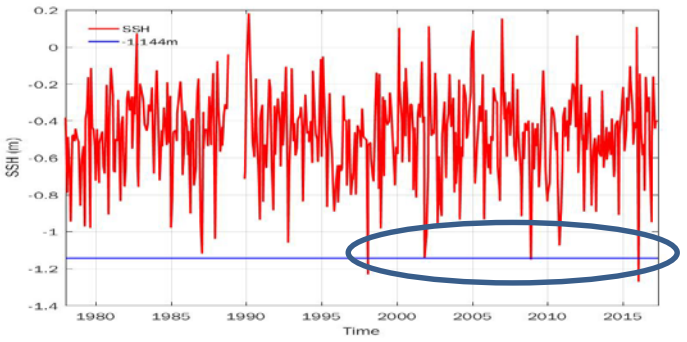
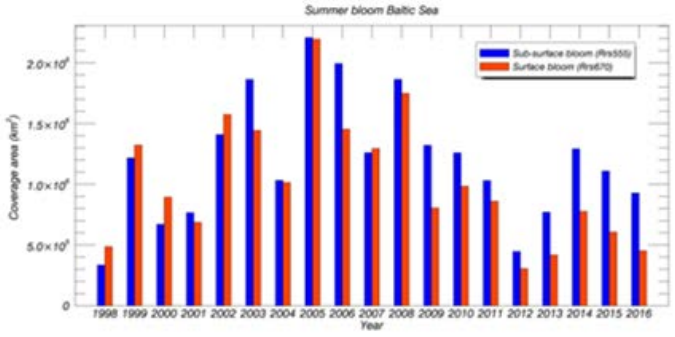
Salinity at Baltic Proper



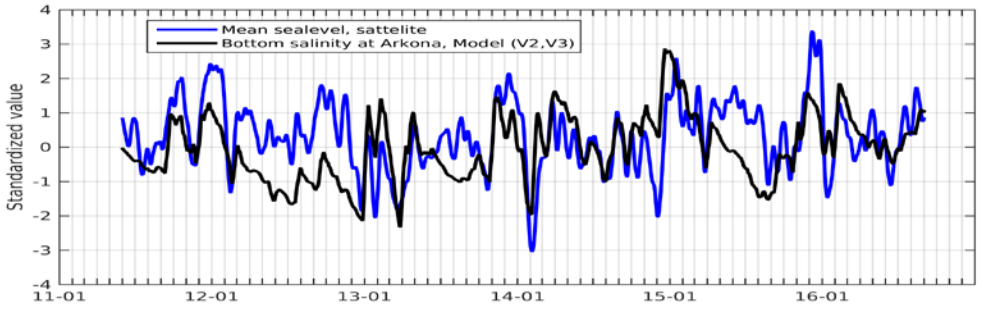
Monthly min. Sea level at Kemi – N. Baltic



Summer bloom
spatiotemporal coverage

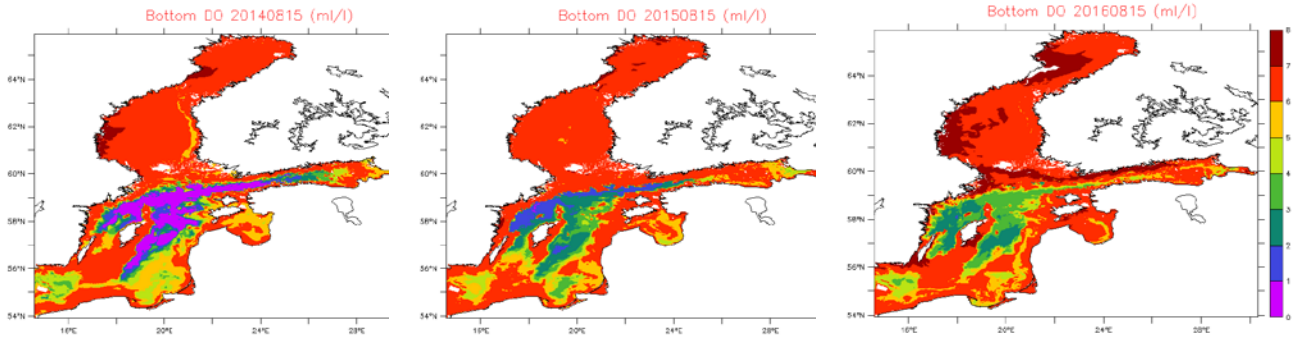


Salinity & mean sea level

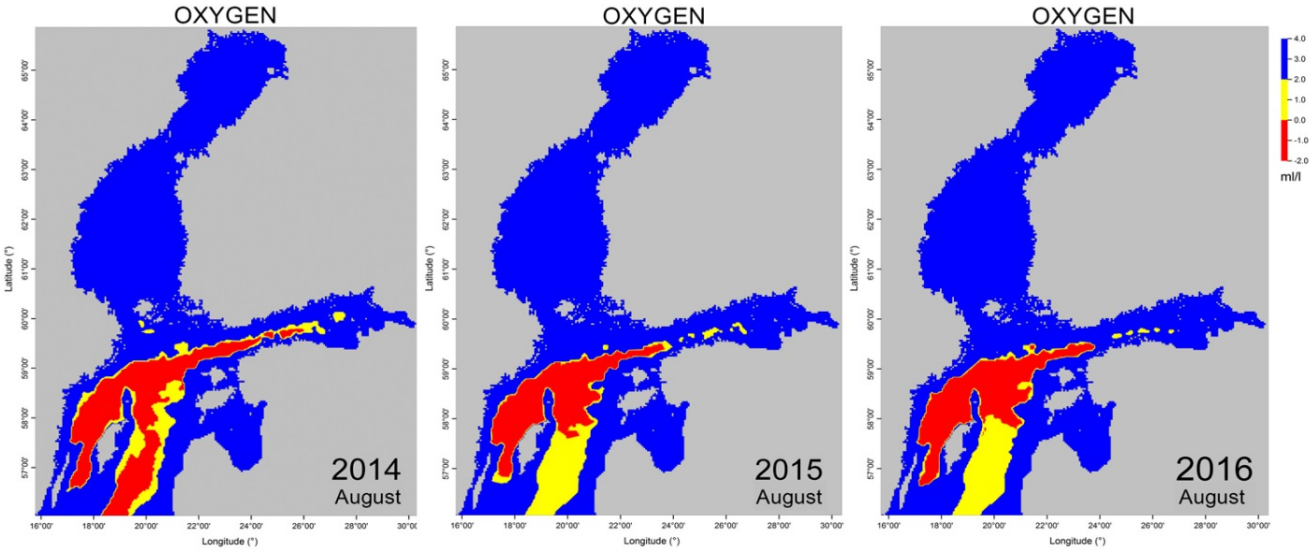


OSR Eutrophication 2016: bottom oxygen

Oxygen situation near the seabed in the Baltic Sea in 15 August 2014, 2015 and 2016, BAL MFC (ERGOM模式底层溶解氧, 2014-16 8.15)



Oxygen situation near the seabed in the Baltic Sea in August 2014, 2015 and 2016 © SYKE (观测底层溶解氧, 2014/16 8.)



LTL response to human & natural pressure
低营养层对人类和自然压力的响应

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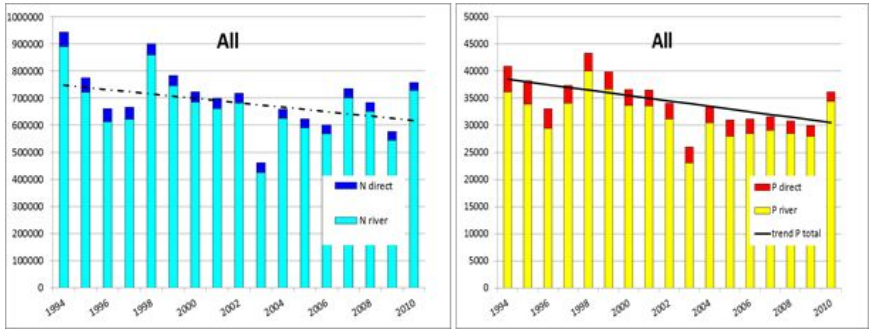
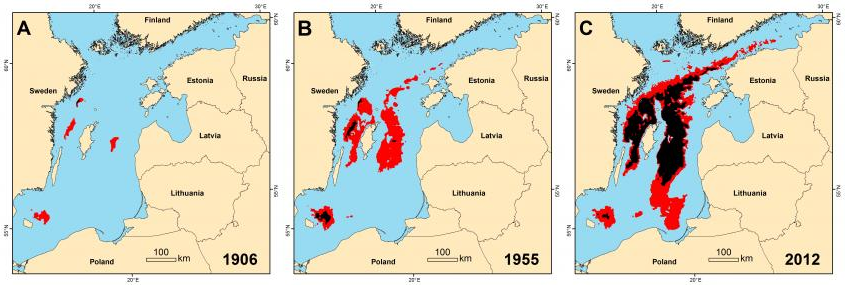
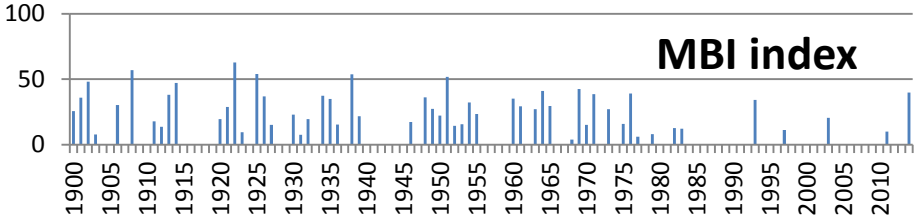
- Nutrient load has been reduced since 1990s
- Eutrophication has not been improved as expected. Climate change (eg increase of temperature) makes the reversal of eutrophication more difficult.
- Oxygen condition was 10 times worse in 2012 than a centuary ago

水携营养盐入海载荷年际变化: **nutrint load**





底层溶解氧: **1906, 1955, 2012;**
red: hypoxia; black: anoxia



波罗的海主要入流事件指数 **(1900-2014)**

Helmholtz-Zentrum Geesthacht
Zentrum für Material- und Küstenforschung

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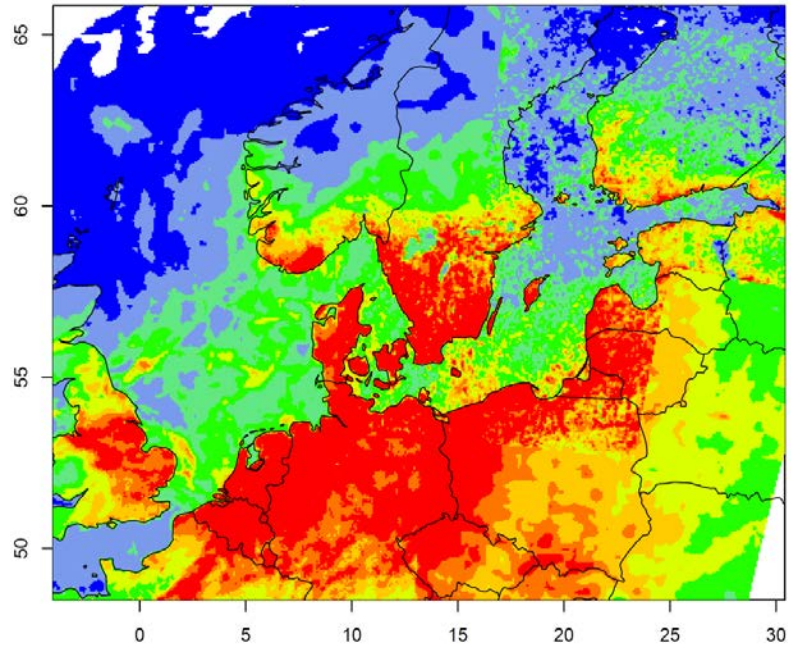
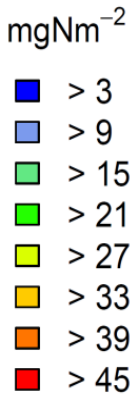
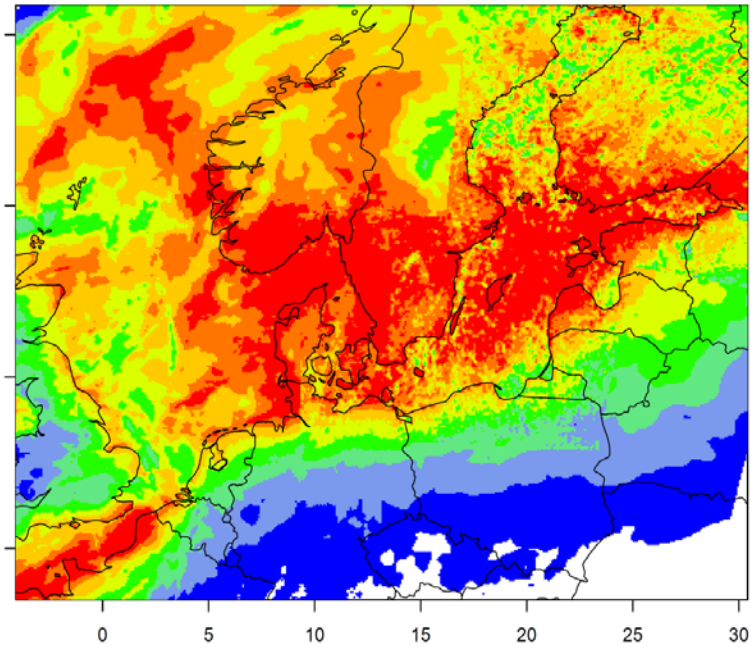
Nitrogen deposition from Shipping

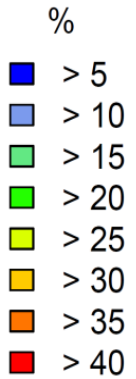
•total deposition of Nox July 2012
•2012年7月大气沉降





contribution by shipping July 2012
2012年7月航运导致的大气沉降





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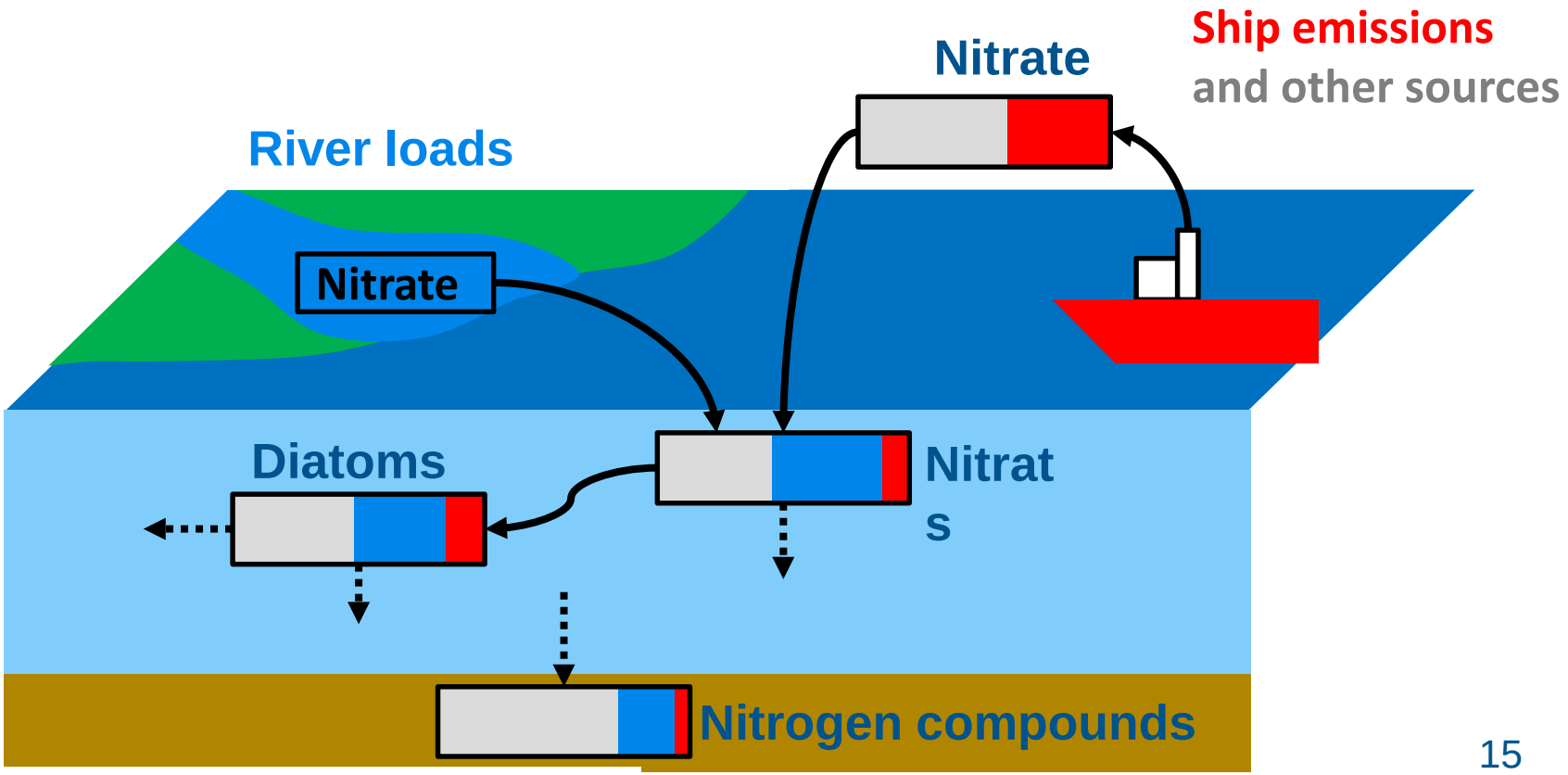
Nutrient tagging

- **Goal:** estimate of contribution of anthropogenic nutrient input to algea blooms and eutrophication (人类活动营养盐输入流动轨迹)
- > Simulations with tagged nitrate input



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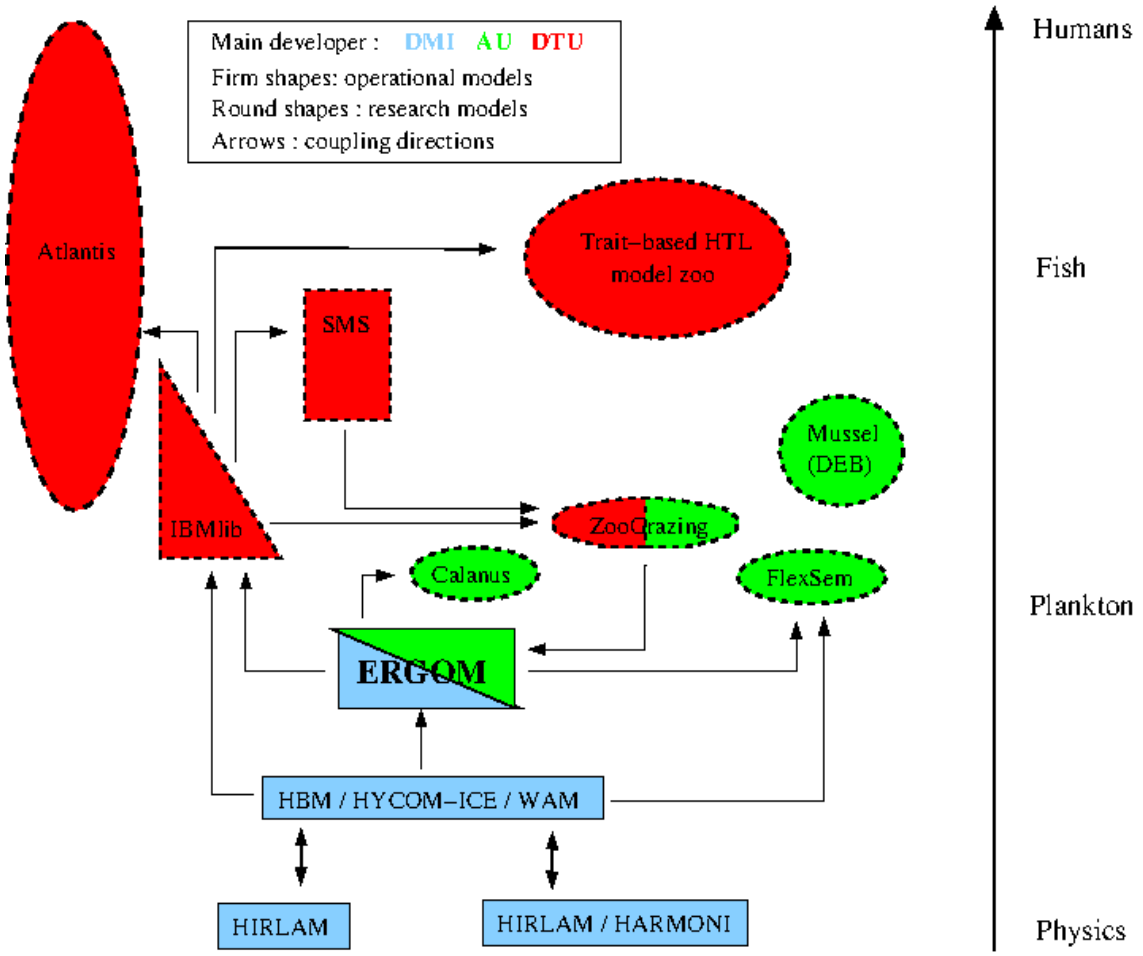
Beyond Eutrophication: end2end modelling (Danish system, 2006-)



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Thank you for your attention!

谢谢！