Monitoring and modeling of phytoplankton and marine primary production

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Outline

- The ”problem” – the Norwegian perspective
- Biomass and ocean dynamics
- Satellite remote sensing
- Marine ecosystem modelling
- Onset of the spring bloom
- Monitoring and modelling of marine productivity
- Indian Ocean modelling

The Problem – Norwegian "view"

- **Eutrophication and Global Change**
- **Increased Transport and Spreading**
- **Harmful Algae Blooms (HABs)**
- **Environmental Effects:**
  - **Fish & Shellfish Aquaculture**
  - **Fisheries & Wild Life**
  - **Coastal Zone Biodiversity**
  - **Health**
  - **Recreation & Tourism**
  - **Off-shore Industry**
  - **etc.**

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How physical processes that influence marine organisms

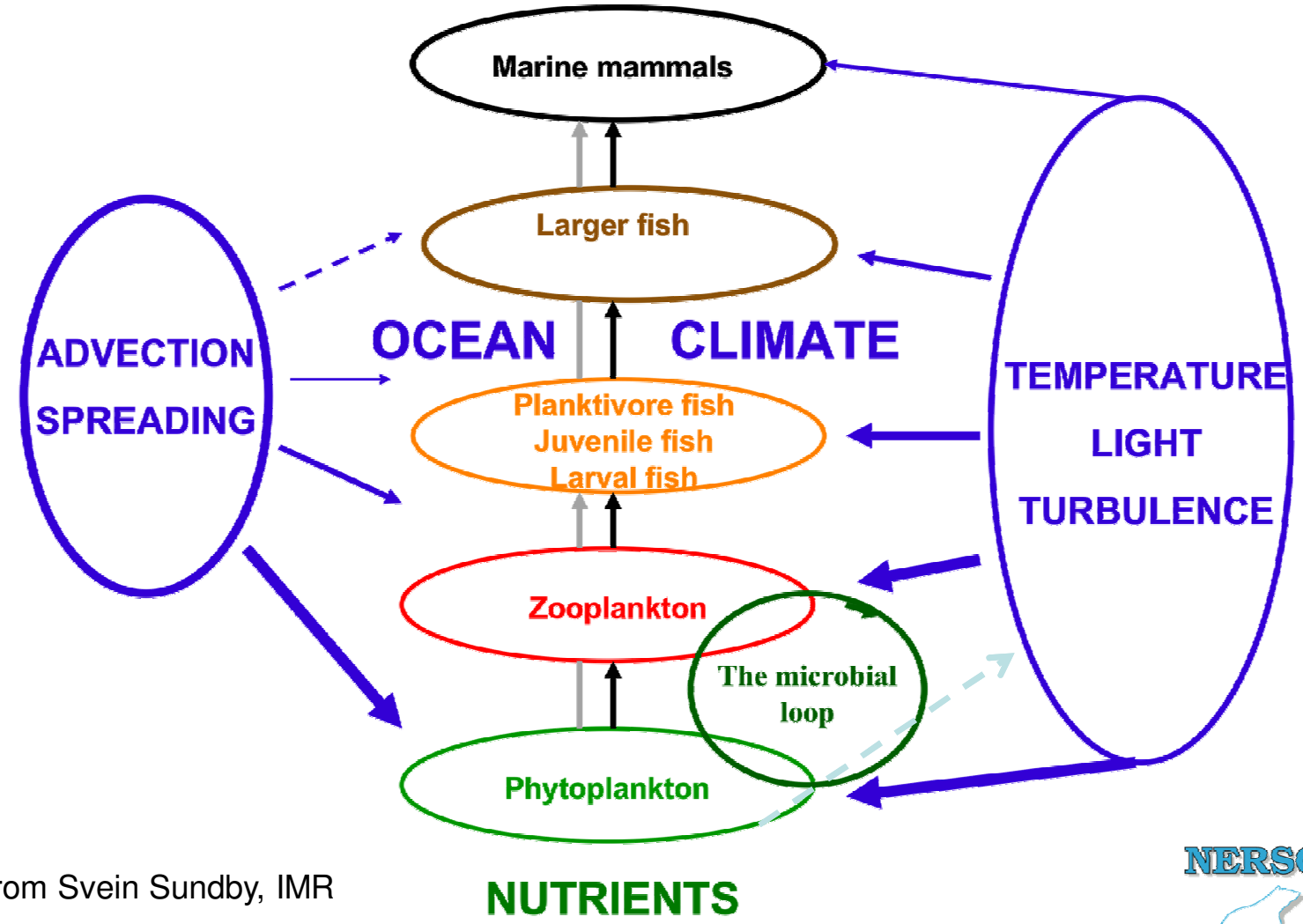
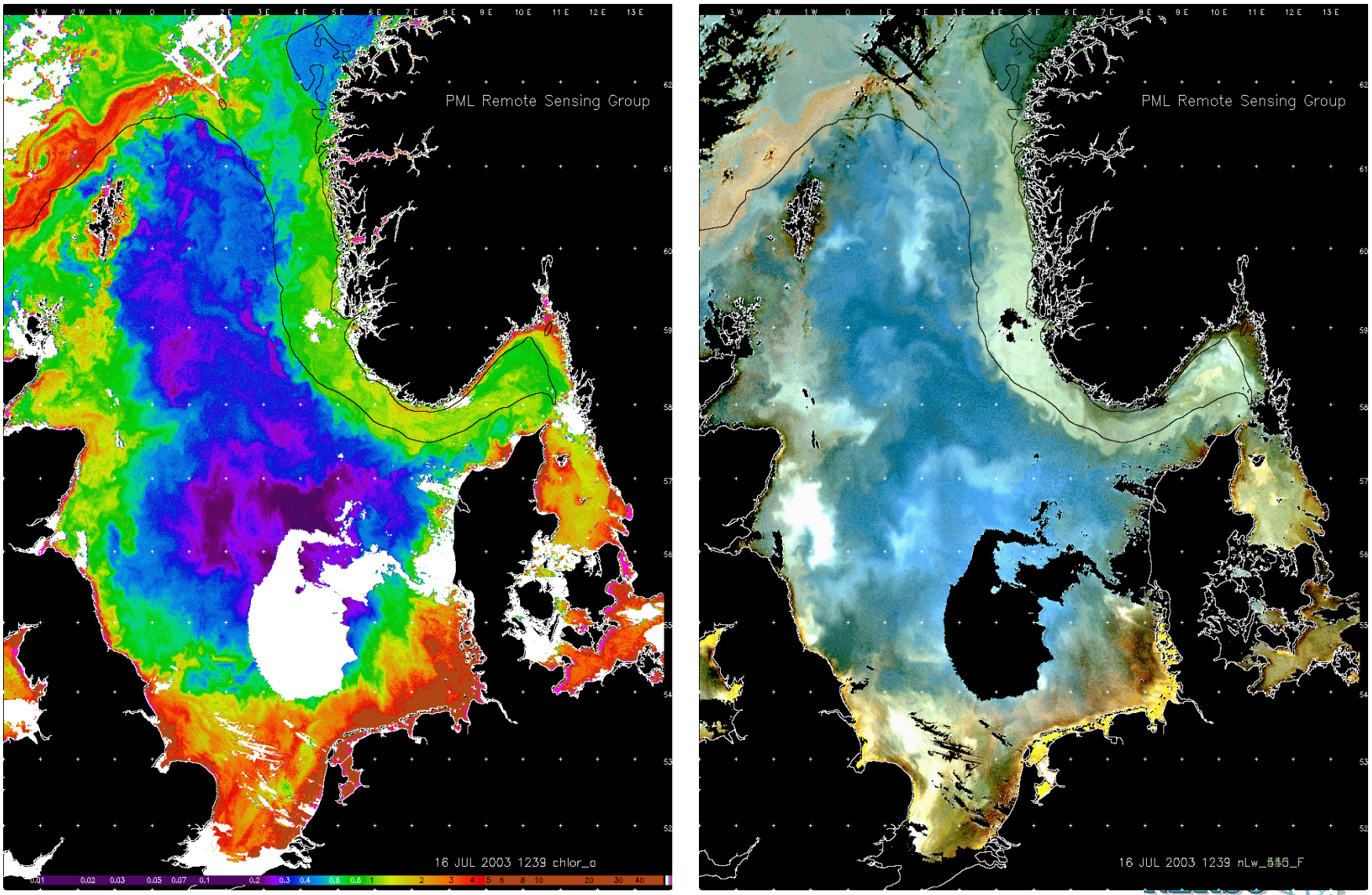


Illustration from Svein Sundby, IMR

Satellite-based parameters

- Bio-physical parameters:
  - Chlorophyll-a concentration - Plankton biomass
  - Totalt Suspended matter - Sediments
  - Dissolved Organic Matter- Yellow Substance (YS)
  - RGB “true” colour image- The water colour
  - Sea surface temperature (SST): Currents and advection of water masses
- Additional parameters
  - Diffuse attenuation coefficient: Light attenuation
  - Solar radiation (PAR): Available light

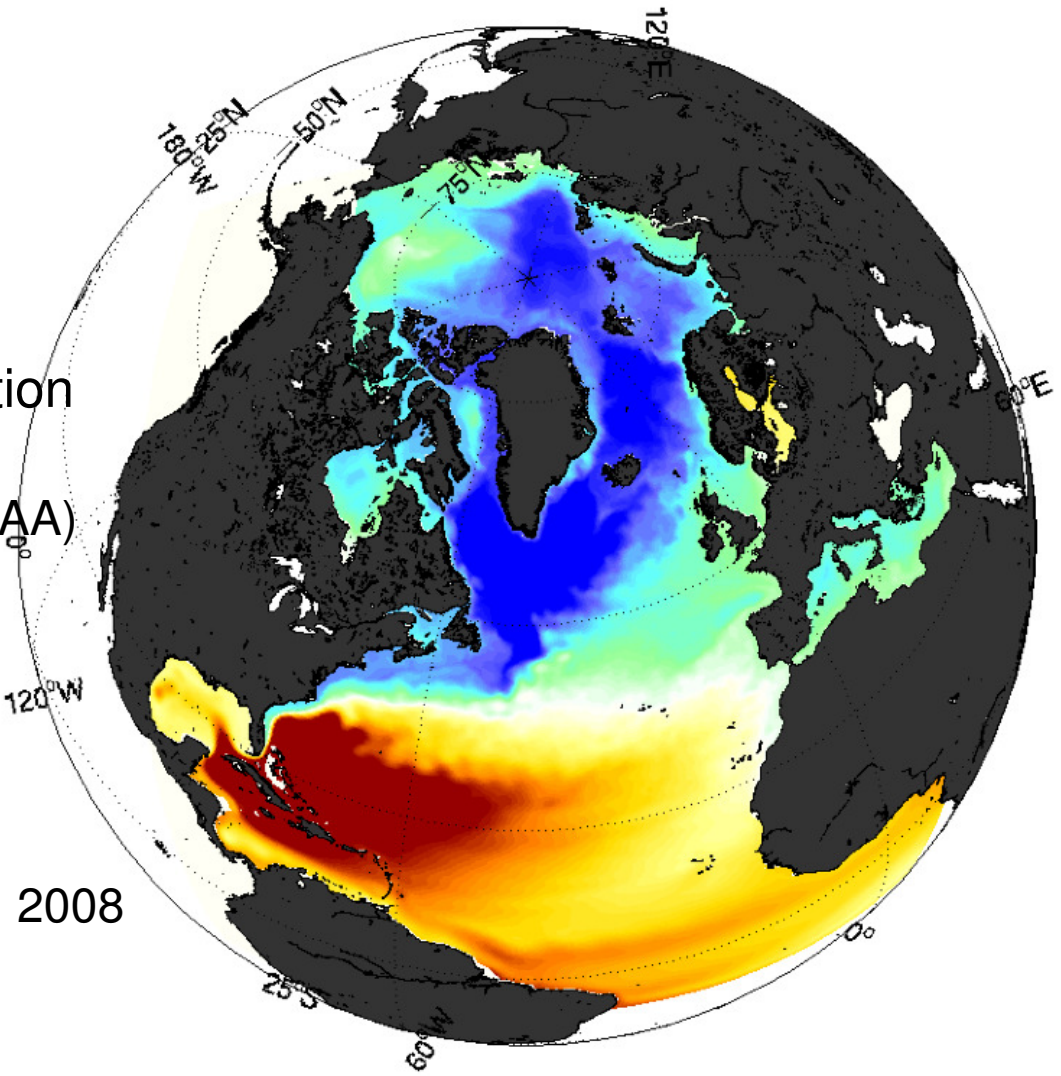
The North Sea “ecosystem” - 16. July 2003



Data courtesy: Remote Sensing Group, PML, UK / NASA SeaWiFS Project

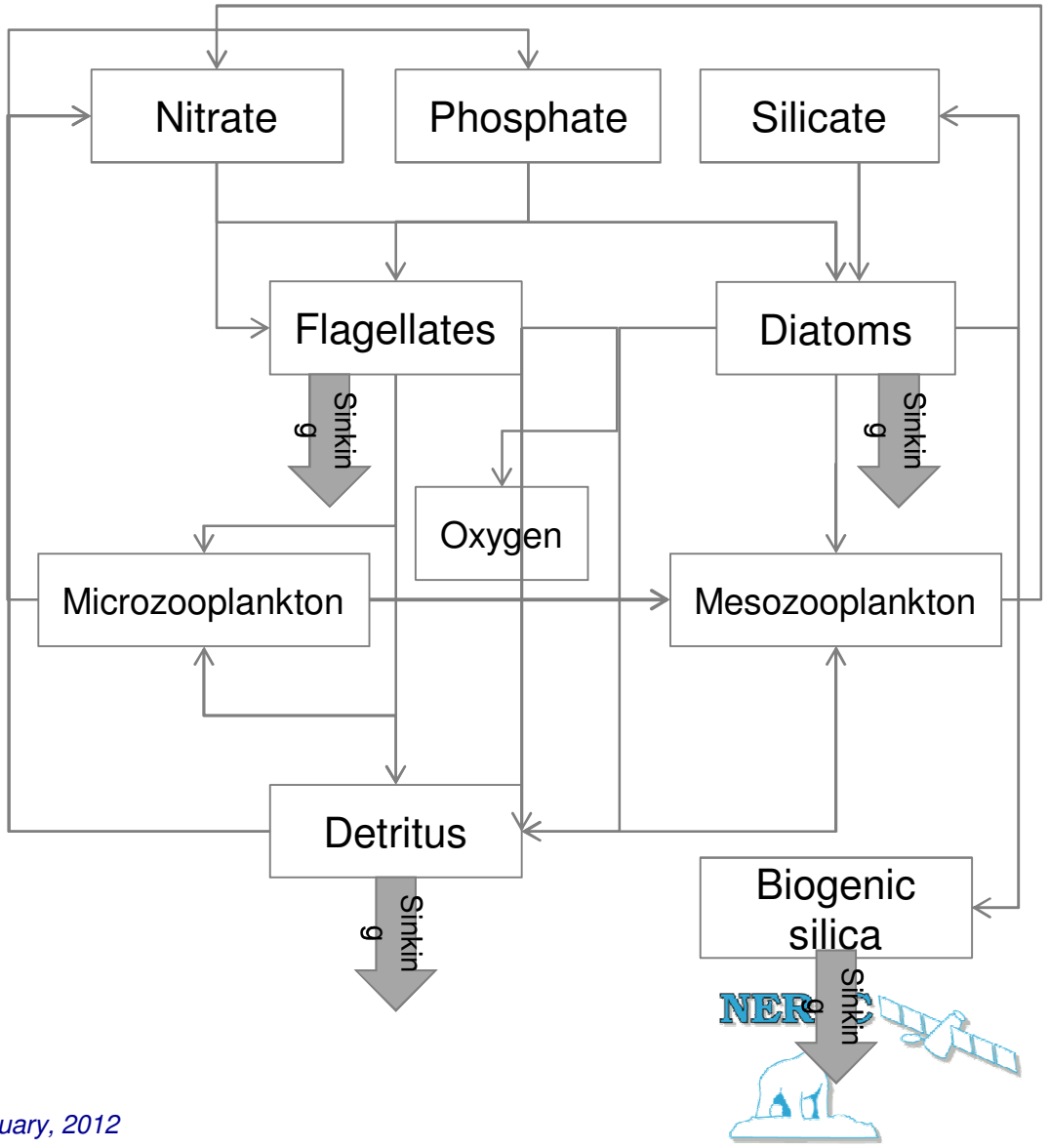
The ToPAZ model system

- ToPAZ3: Atlantic and Arctic
  - HYCOM + EVP sea-ice model
  - 11-16 km horizontal resolution
  - 22 hybrid layers
- EnKF
  - 100 members
- Observations and Data assimilation
  - Sea Level Anomalies (CLS)
  - Sea Surface Temperatures (NOAA)
  - Sea Ice Concentration (NSIDC)
  - Sea ice drift (CERSAT)
  - Argo T/S profiles (Coriolis)
- Runs weekly, 10 days forecasts
  - ECMWF forcing
  - Exploited at met.no since March 2008
- Set up for the Indian Ocean

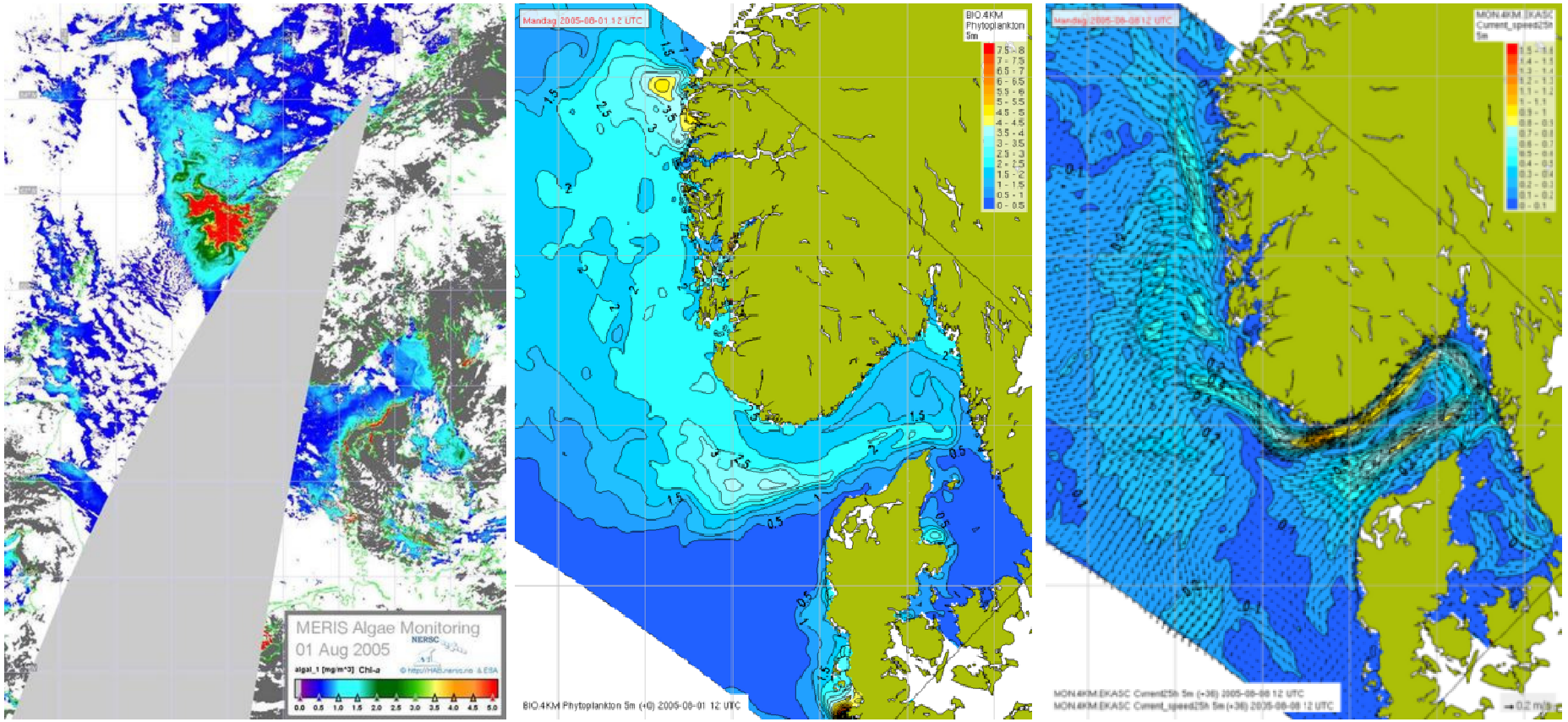


Couple physical-biological model

- NORWECOM
  - Implemented in V2.2 of HYCOM
  - started from Climatology in 1996
  - Use nutrients in rivers from GlobalNEWS hydrological model
  - Hindcast and testing



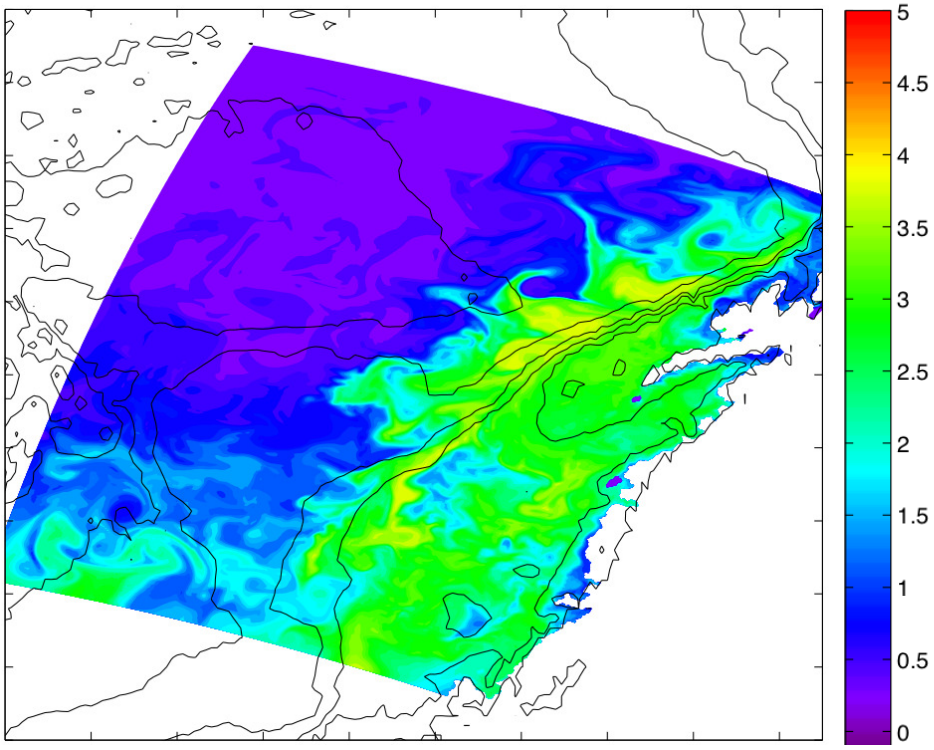
Monitoring and Modelling:
Near real-time bloom prediction - 1. August 2005



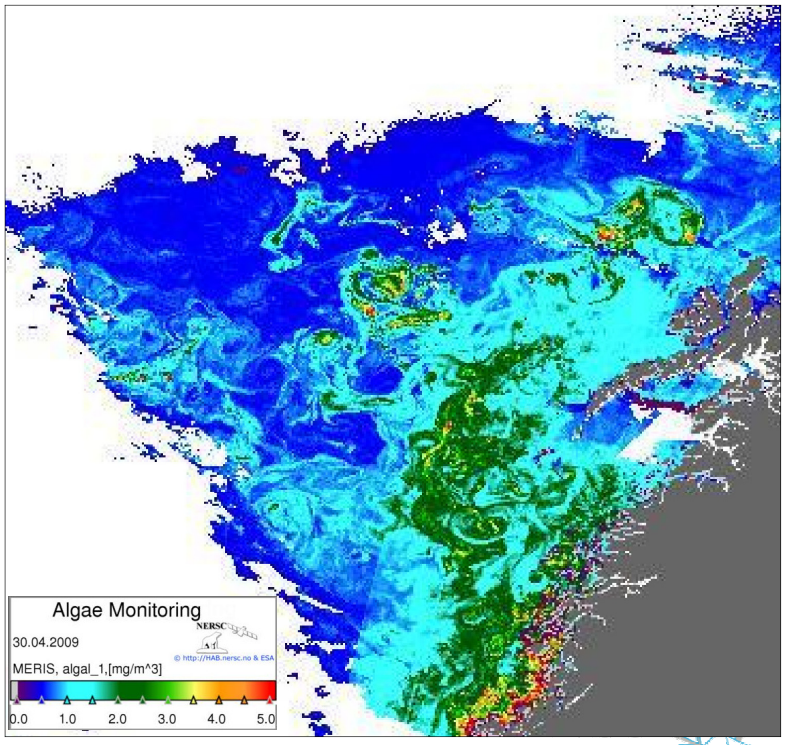
http://HAB.nersc.no http://moncoze.met.no

Nested NORWECOM

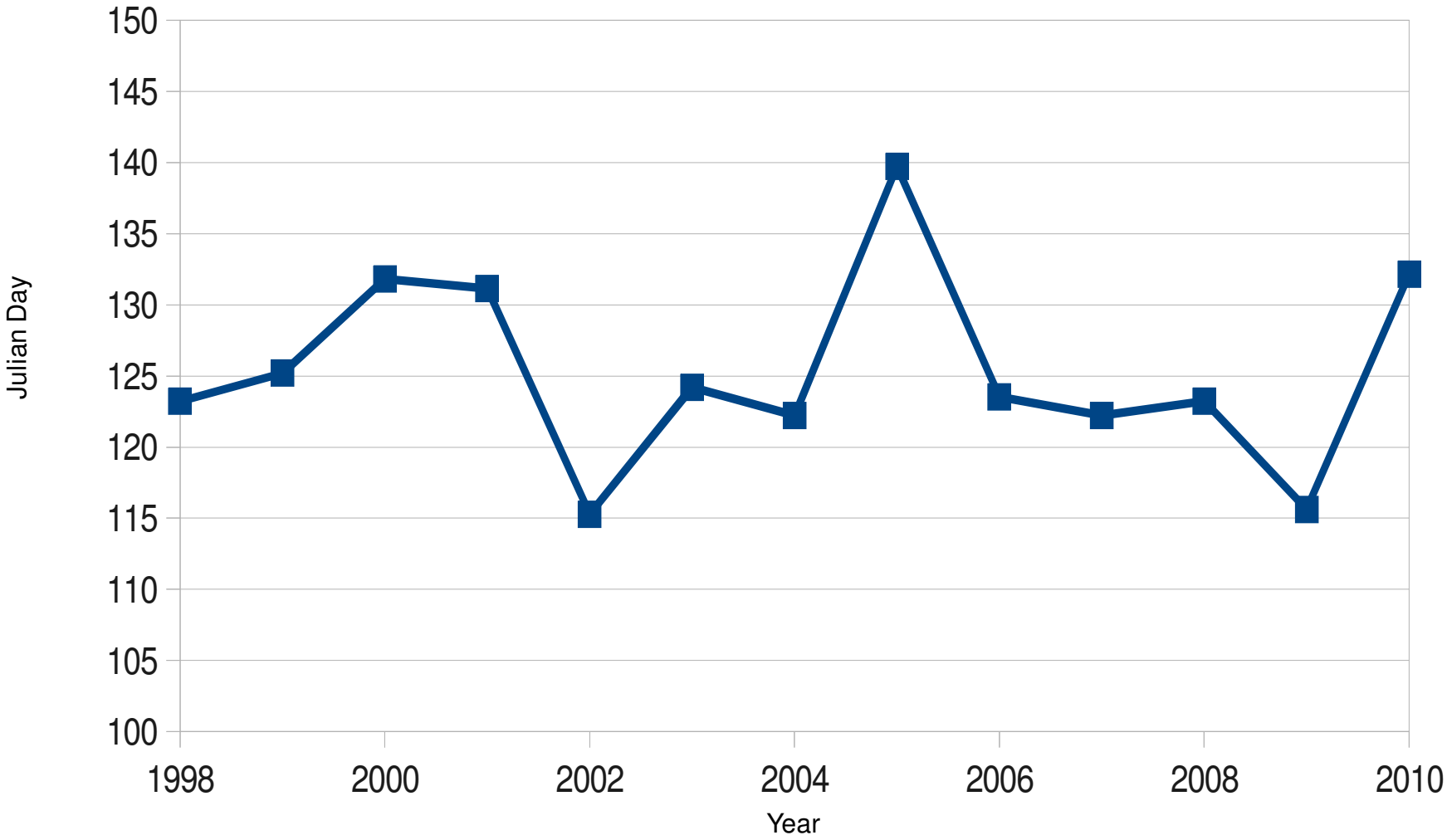
Model snapshot of surface chlorophyll in the end of April in HYCOM-NORWECOM
The model resolution is 2.3 km



Satellite image of chlorophyll from the same area on April 30, 2009.



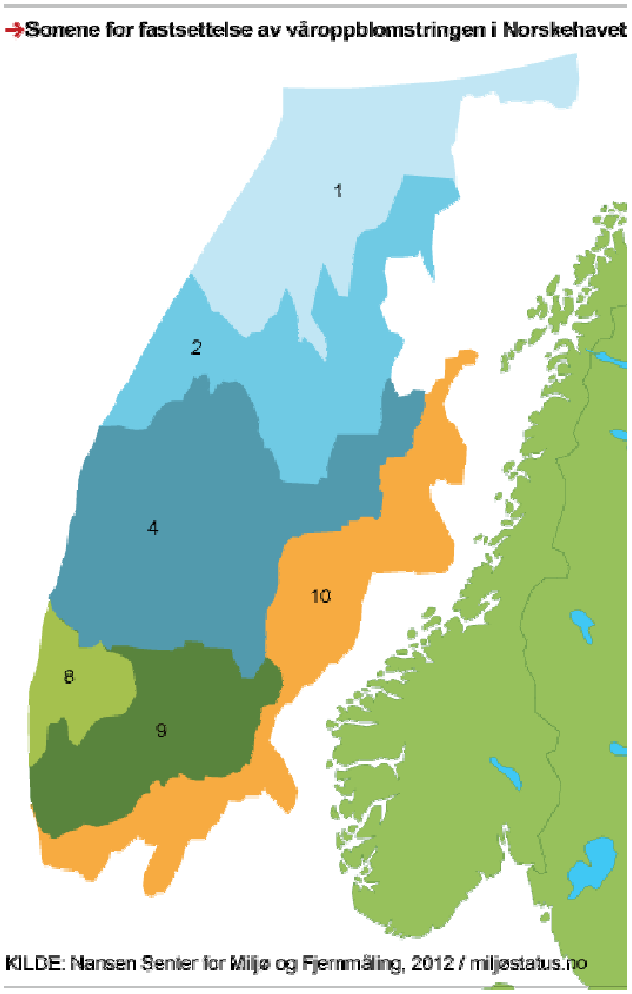
Onset of spring phytoplankton bloom from satellite data

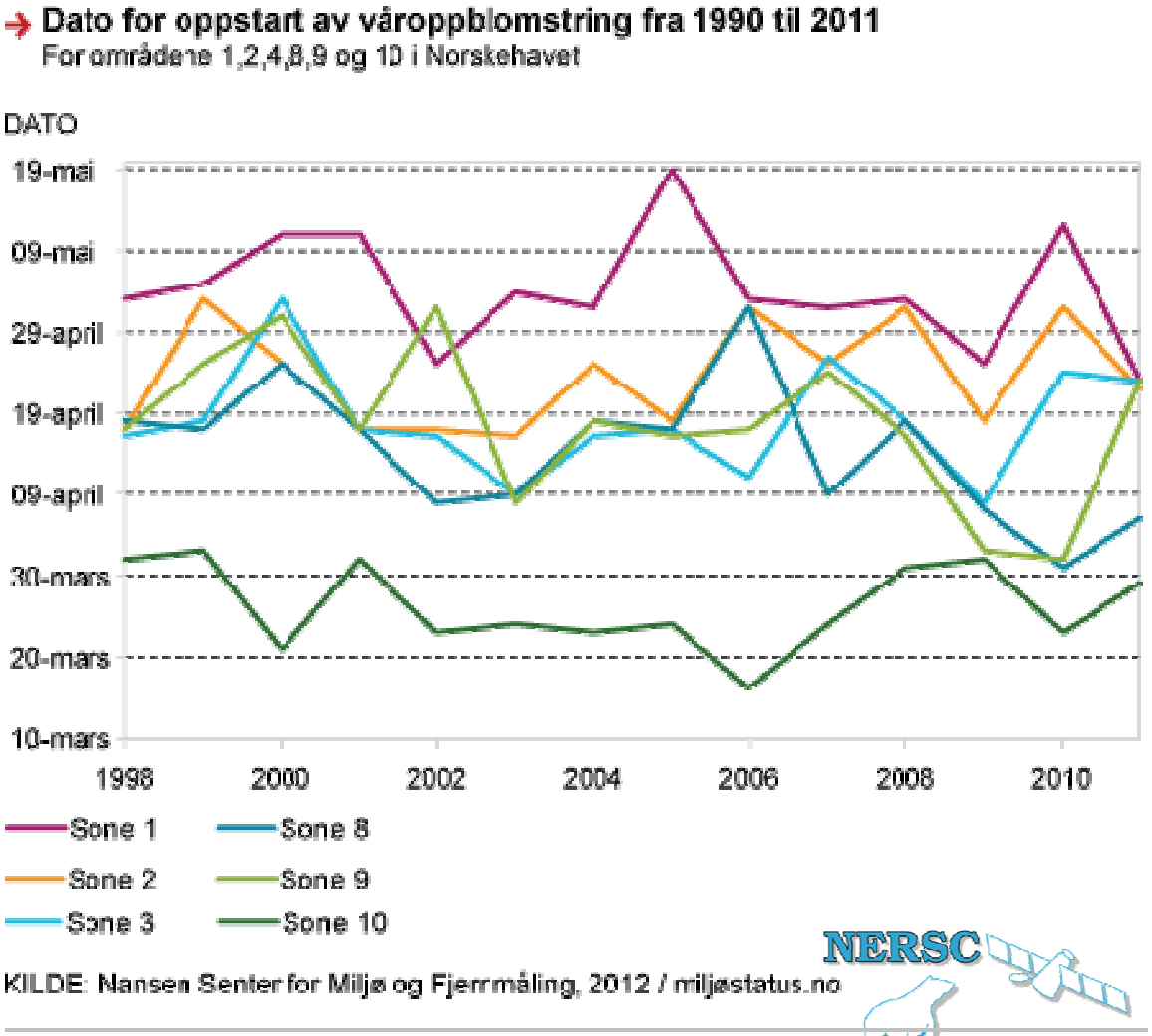


Typical seasonal dynamics of chlorophyll, mixed layer depth, wind and temperature

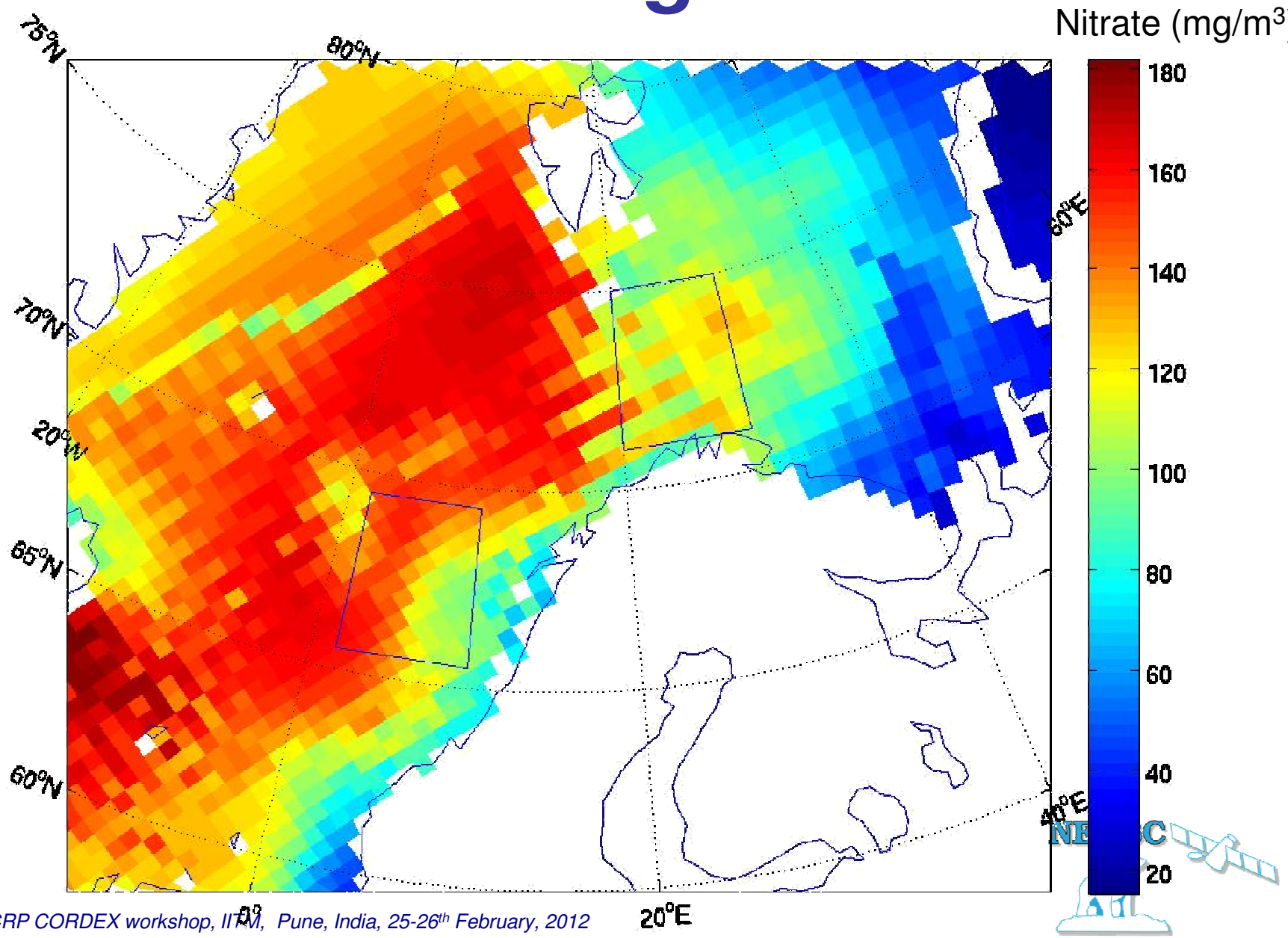
Day for onset of the spring bloom in the Norwegian Sea

Onset of the Spring bloom – Norwegian Sea

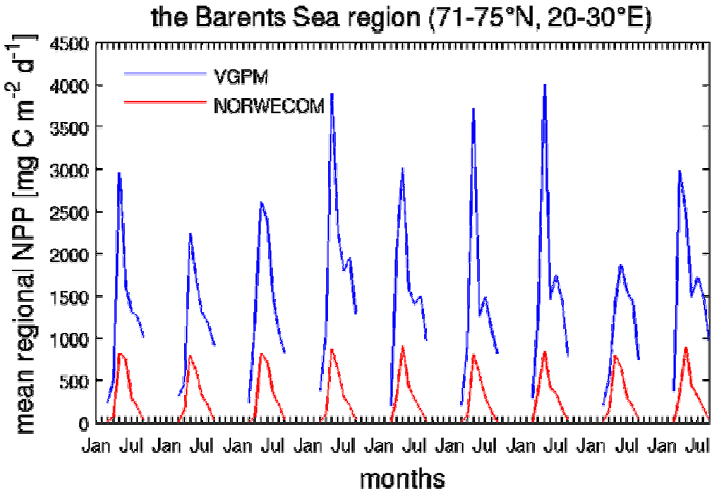


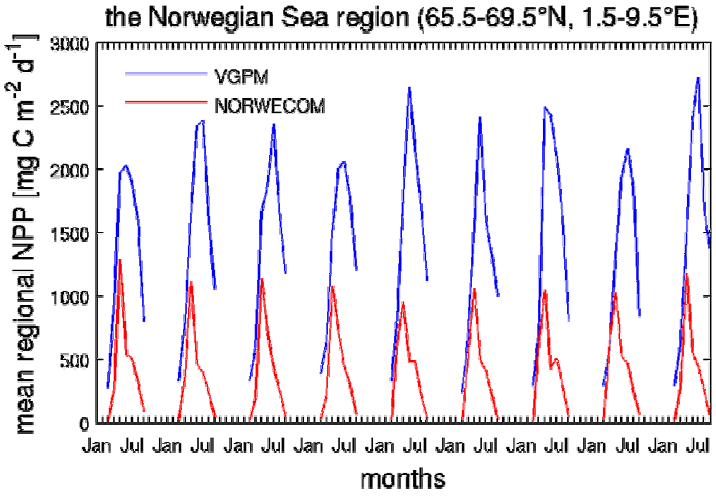


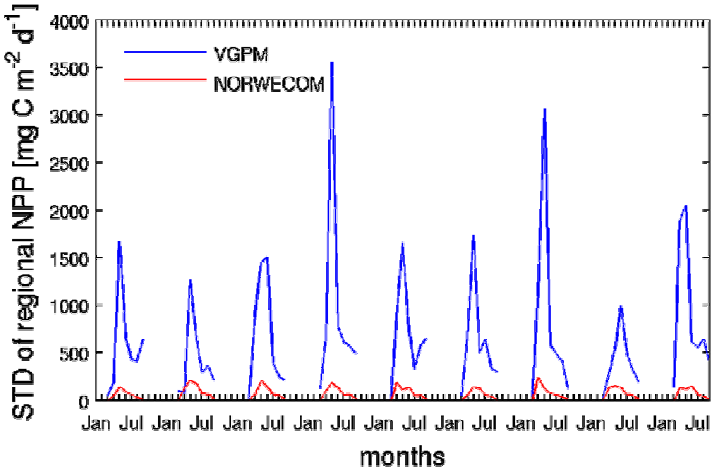
The Norwegian Sea

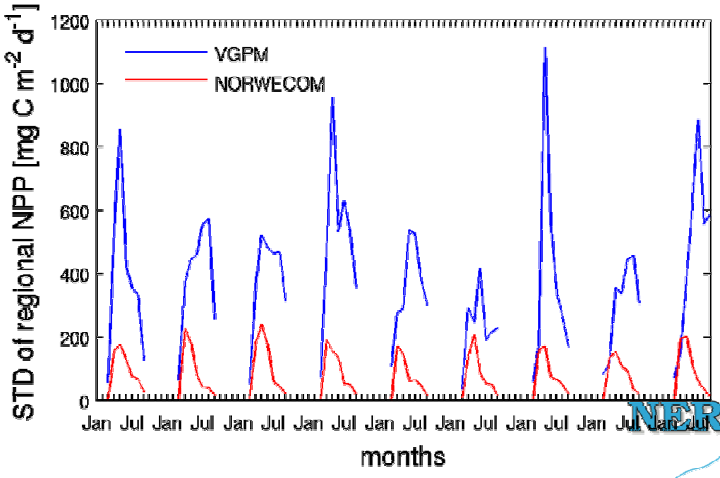


Primary production
Nordic Seas (1998- 2006)

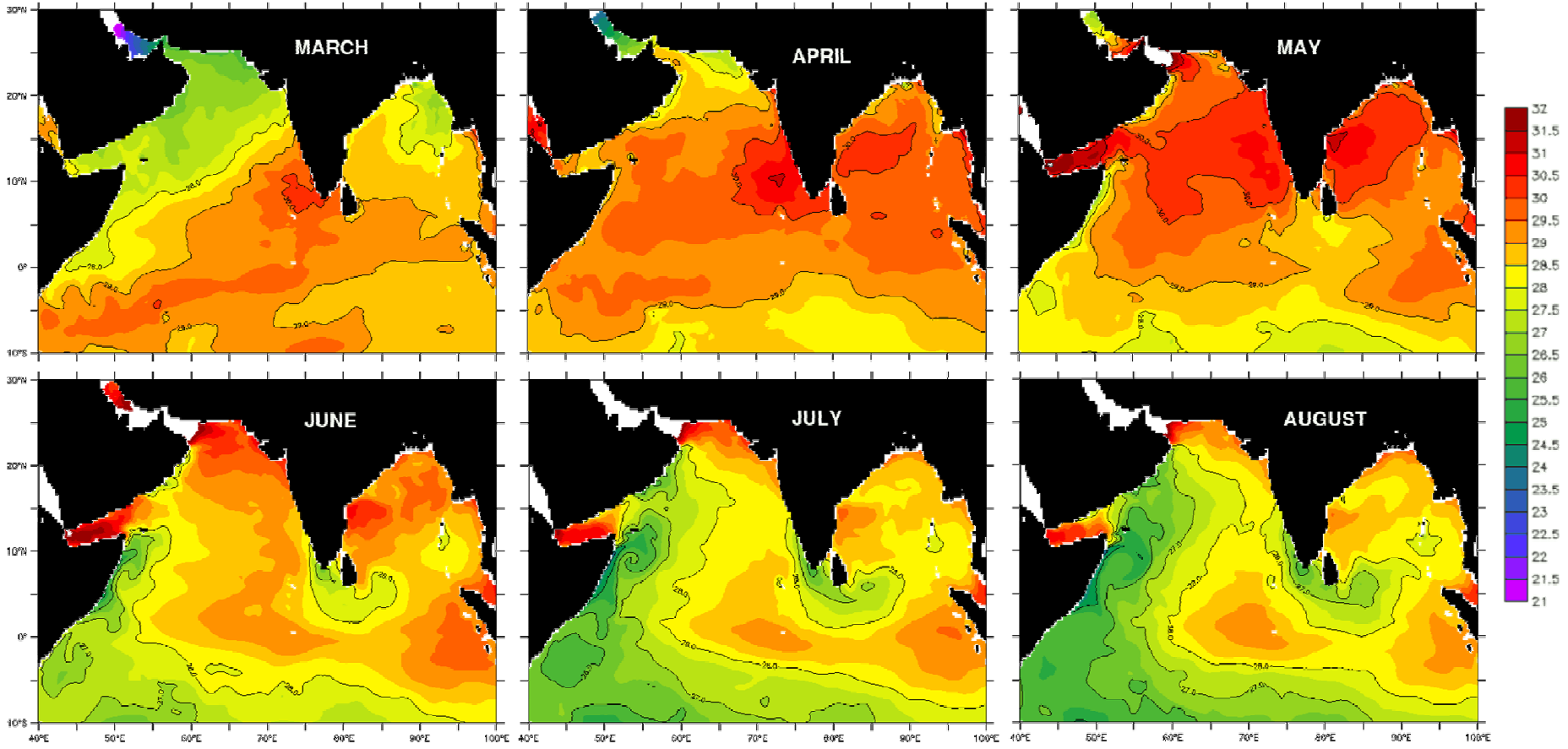








ToPAZ:
Modeled Sea Surface Temperature



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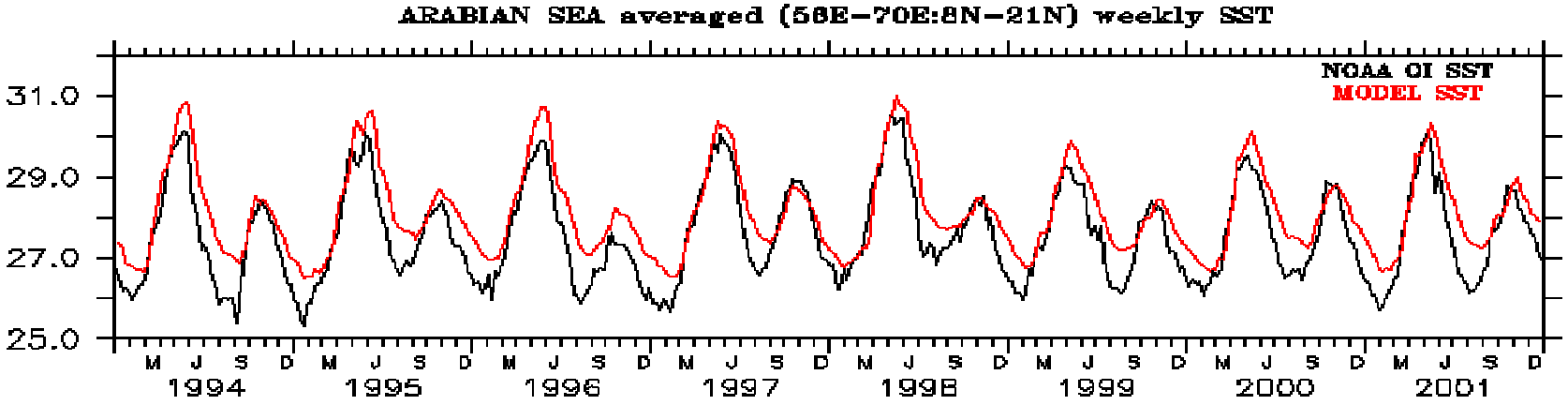
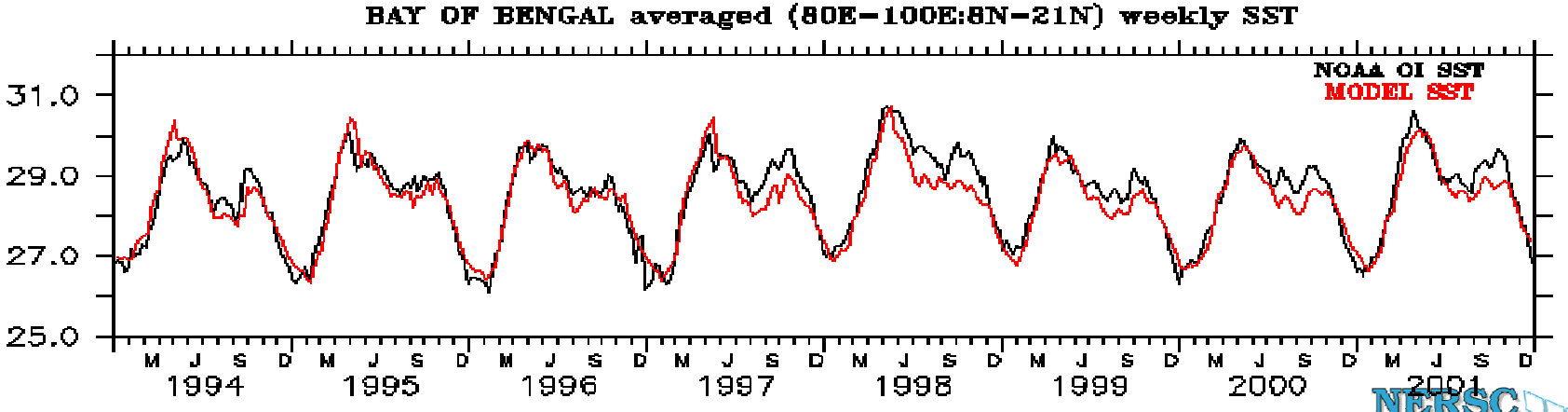
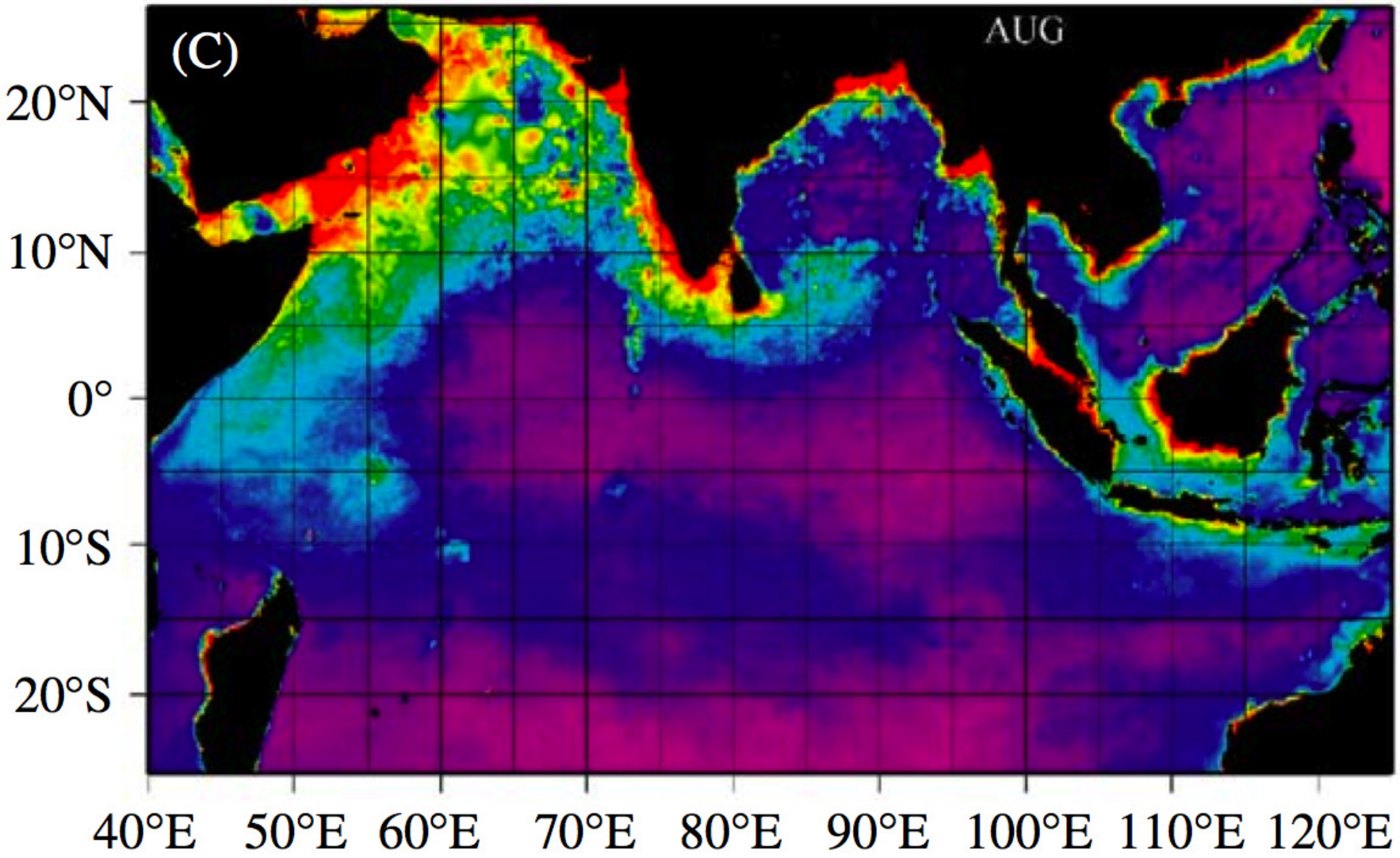
Validation against Satellite Sea Surface Temperatures







Wiggert, J. D., Murtugudde, R. G., and Christian, J. R., 2006. Annual ecosystem variability in the tropical Indian Ocean: Results of a coupled bio-physical ocean general circulation model, Deep Sea Research Part II: Topical Studies in Oceanography, 53, 644-676

Summary - Indian Ocean ecosystem

- Indian (ISRO), European (ESA) and US satellite EO based monitoring systems
- Regional and global verified EO products are available
- Assimilation of EO, in situ and Argo data in models
- Regional high resolution coupled ocean model
- Ecosystem model (to be) implemented
- Results to be validated
- To be used in climate assessment and adaptation studies

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