Real time monitoring and modelling at SINTEF

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Environmental Monitoring and Surveillance:
Challenges, Solutions and Opportunities Workshop

Porto, December 2014

Marine Research at SINTEF

SINTEF

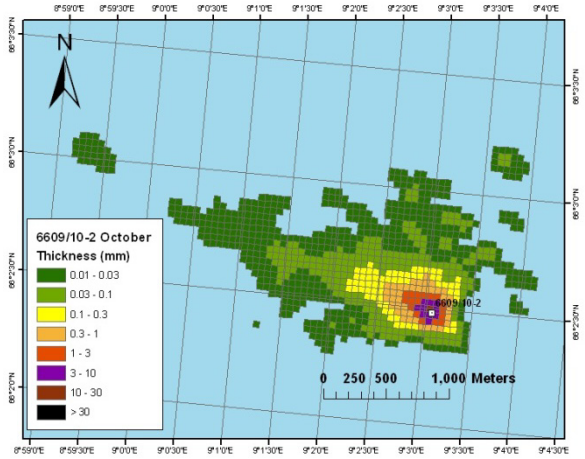
Environmental Technology

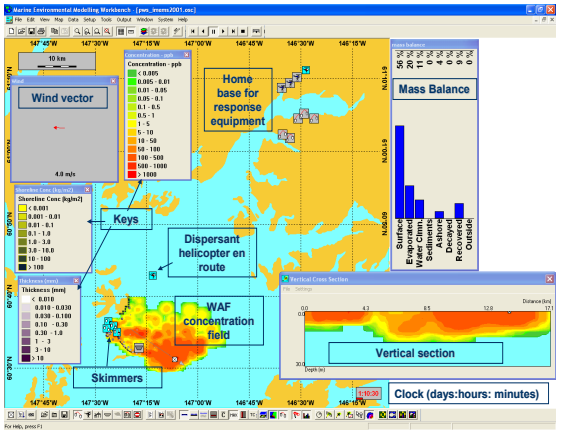
One of the most acknowledged and largest R&D institutes on oil research worldwide

- World's largest database on oil weathering properties of crude and bunker oils
- Internationally leading R&D group on use and application of dispersants on surface and sub surface oil spills

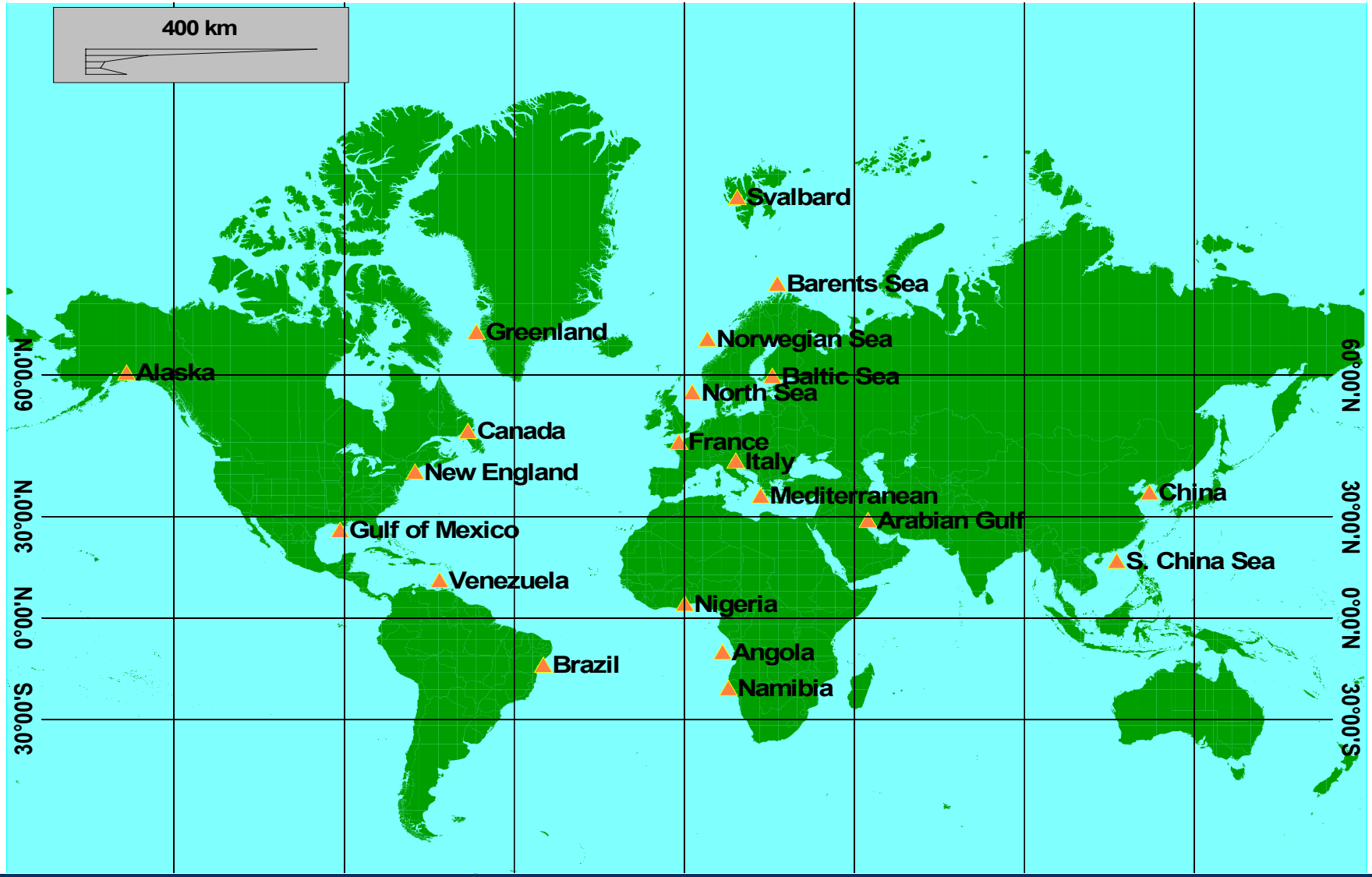
Department of Environmental Monitoring and Modelling

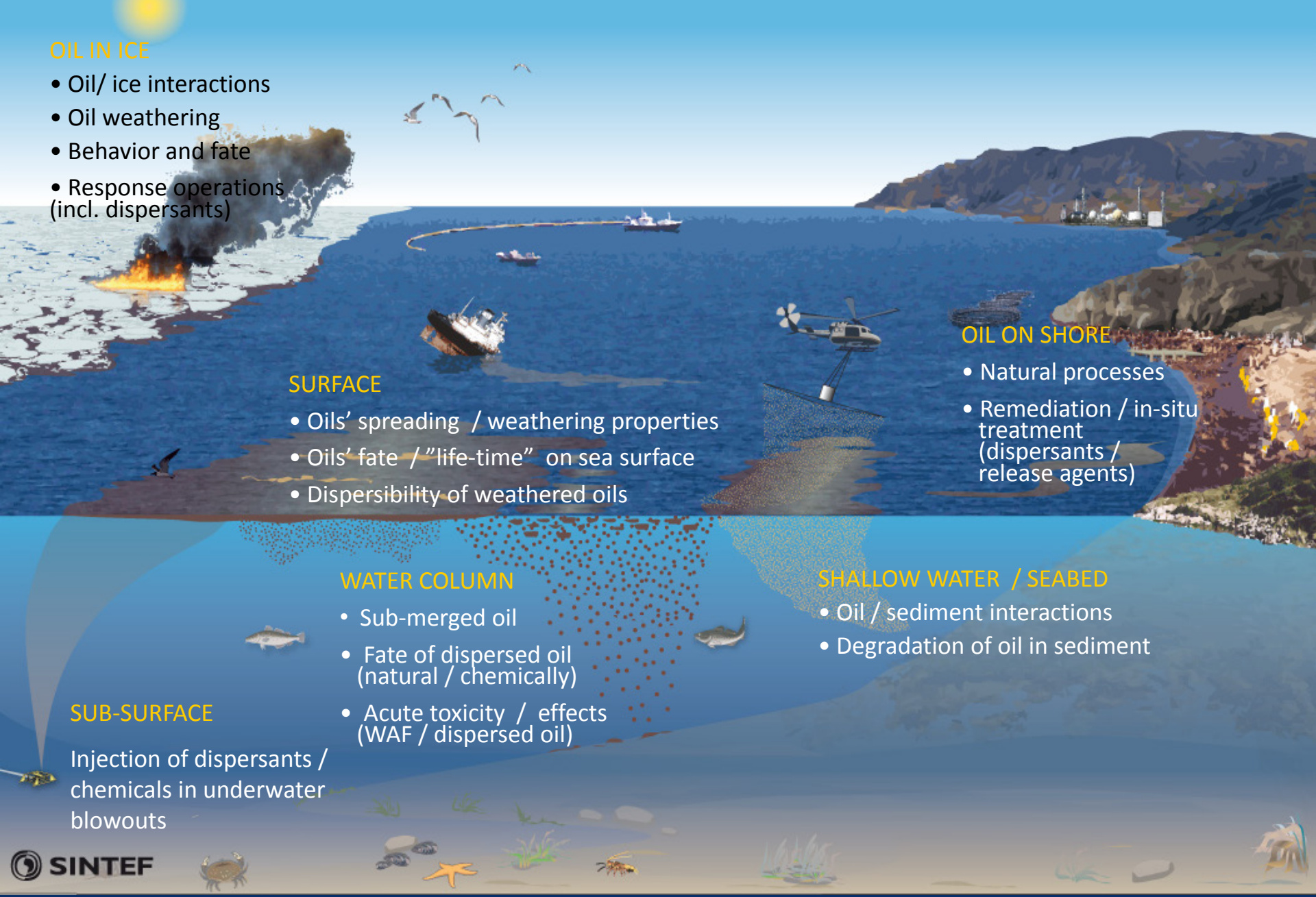
- Developed and operates the most comprehensive, operational oil spill modelling tool on the market (OSCAR – Oil Spill Contingency And Response)
- Developed operational modelling tools for regular releases of produced water and drilling discharges which are in progress of being industry standards within the largest oil & gas companies world wide (DREAM – Dose Response Environmental Assessment Model)





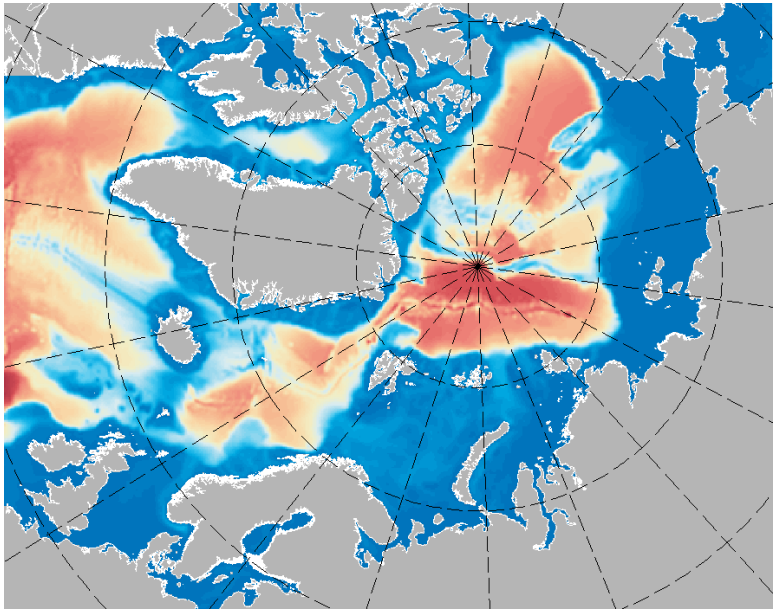
OSCAR / DREAM Application Areas

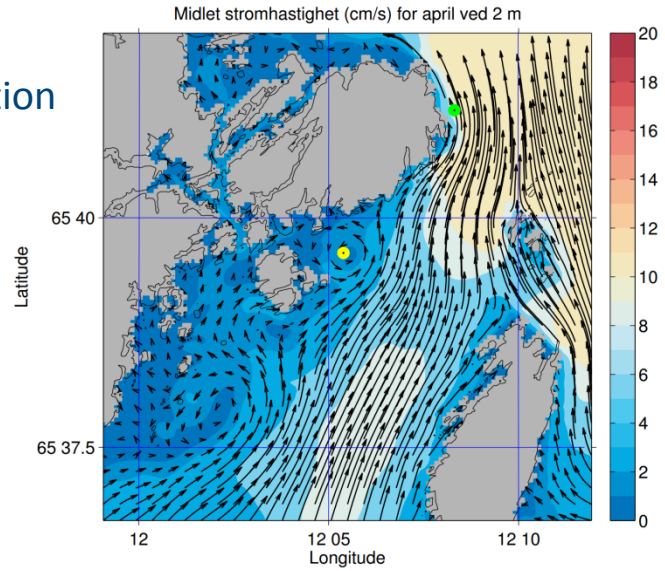


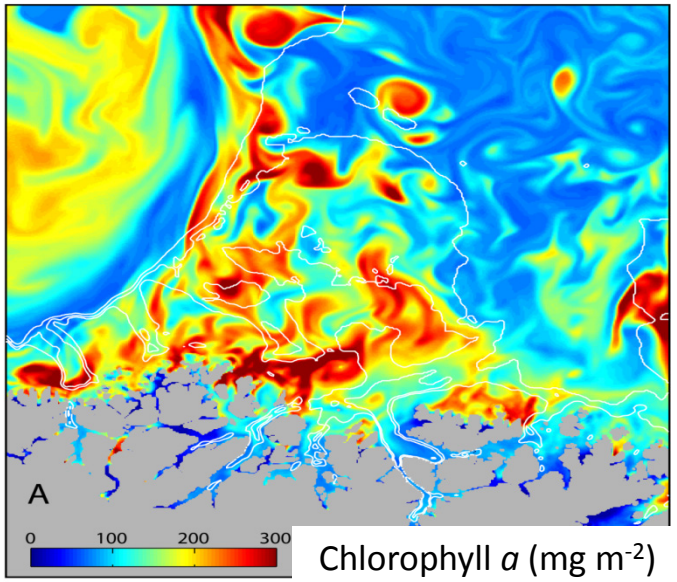

OIL IN ICE
• Oil/ ice interactions
• Oil weathering
• Behavior and fate
• Response operations (incl. dispersants)
SURFACE
• Oils' spreading / weathering properties
• Oils' fate / "life-time" on sea surface
• Dispersibility of weathered oils
OIL ON SHORE
• Natural processes
• Remediation / in-situ treatment (dispersants / release agents)
WATER COLUMN
• Sub-merged oil
• Fate of dispersed oil (natural / chemically)
• Acute toxicity / effects (WAF / dispersed oil)
SHALLOW WATER / SEABED
• Oil / sediment interactions
• Degradation of oil in sediment
SUB-SURFACE
Injection of dispersants / chemicals in underwater blowouts
SINTEF

Department of Marine Resources Technology: Marine Modelling

- Development and application of the SINMOD ocean model with coupled physics and ecosystem for Norwegian and Arctic seas
- Sea ice model based on Hunke & Dukowicz and Hibler
- Nesting; scale from 20 km horizontal resolution down to 32 m
- High vertical resolution near surface, lower resolution in deeper waters
- Hindcast or forecast simulations, assimilation of field data



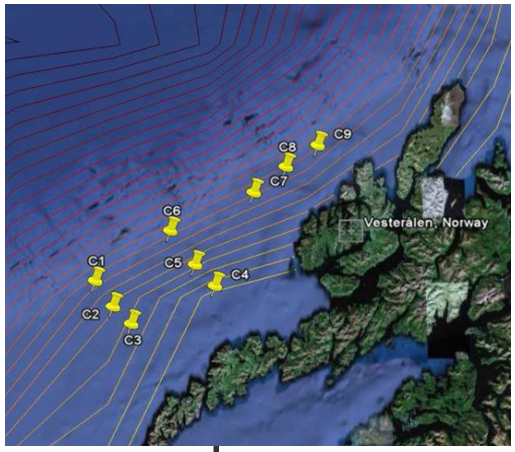




Chlorophyll *a* (mg m^{-2})

LoveCur: summary

Validation program for 6 models against data from 9 ADCPs in the Lofoten and Vesterålen area

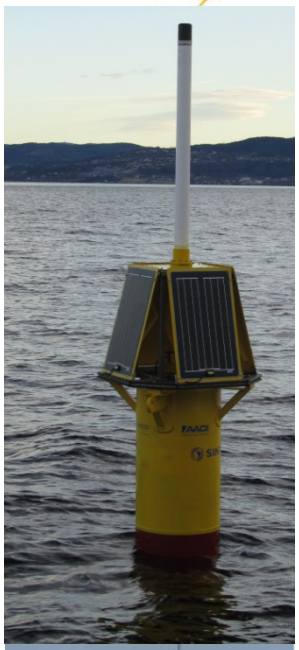


ROMS SINMOD

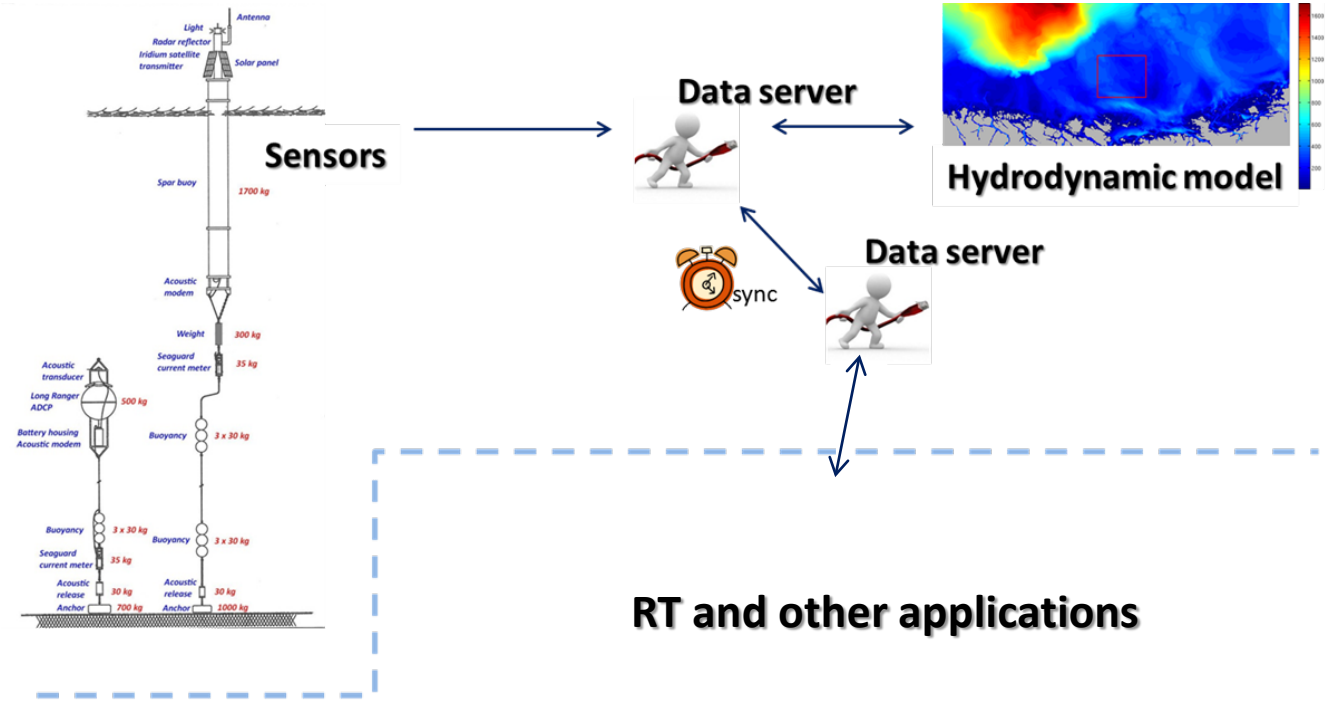
Comparison	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Semi-diurnal tidal current amplitude	Too large near bottom	Stronger currents under-estimated	Slight under-estimation	Greatly over-estimated	Good agreement	Slight under-estimation
Semi-diurnal tidal current orientation and phase	Good agreement	Good agreement	Poor agreement	Poor agreement	Good agreement	Poor agreement
Diurnal tidal current amplitude	Large scatter	Slight over-estimation	Greatly under-estimated	Greatly under-estimated	Slight under-estimation	Under estimated
Diurnal tidal current orientation and phase	Good agreement	Good agreement	Poor agreement	Good agreement	Slight phase error	Poor agreement
Residual current time series	No skill	No skill	No skill	No skill	No skill	No Skill
Current speed probability distribution	Large over-estimation	Slight over-estimation at 99%. Good agreement at 99.9%	Slight under-estimation	Large under-estimation	Un-biased, but larger scatter than Model 2	Too small near the surface and too large near the bottom
Current roses	Too narrowly concentrated around mean direction	Good agreement	Good agreement	Small errors in mean direction	Slightly narrower directional spread than measurements	Mean directions do not agree with measurements
Temperature	Biased low	Good agreement	Biased low	Biased low	Biased slightly high	Drifts to higher temperatures
Salinity	Slight high bias	Biased low	Biased low	Biased low	Slight low bias	Large low bias

Table 5.1. Summary of comparisons between hindcasts and observations.

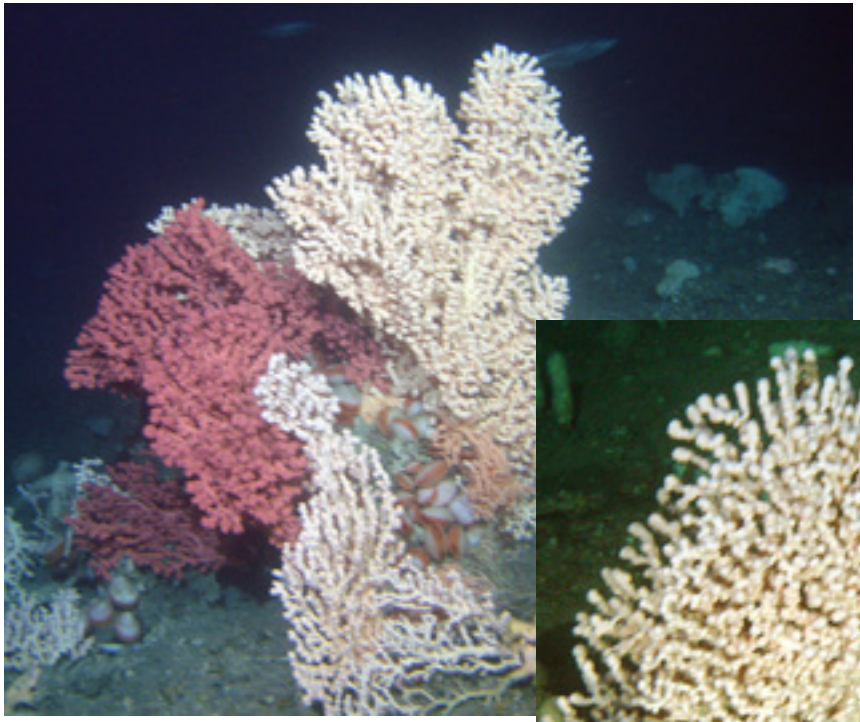
Environmental monitoring – Buoy George: overall architecture of applications



Combination of model and measurement to give the best possible predictions



SPE-164949-MS
A Real-Time Discharge Modelling and Environmental Monitoring System for Drilling Operations - Pilot

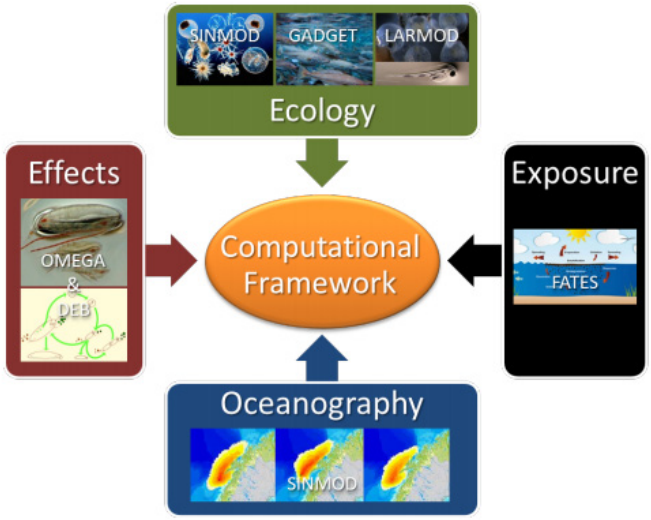


Lophelia Pertusa
(NOAA/Wikipedia)

Statoil

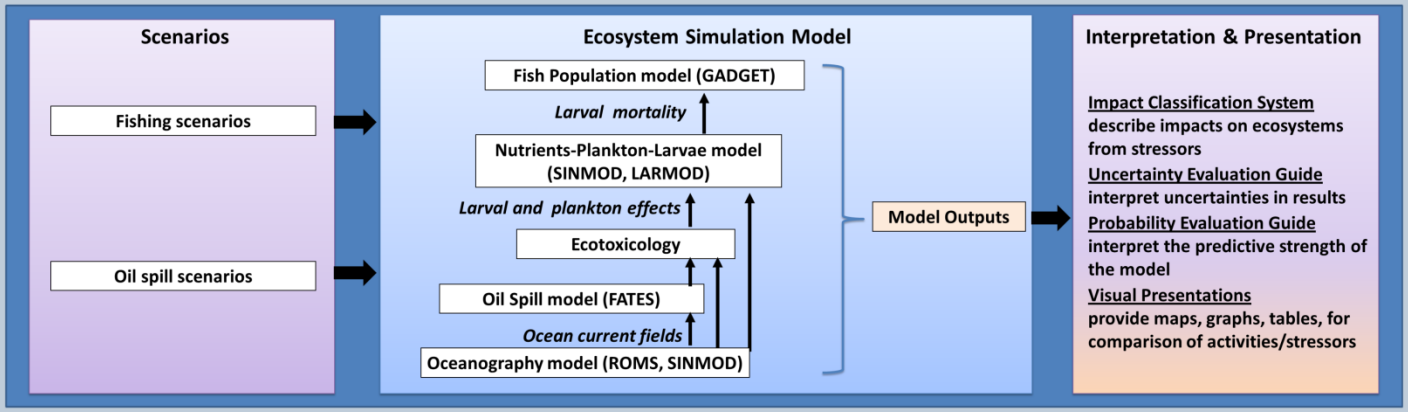
SYMBIOSES – an integrated modeling framework for decision support in marine ecosystem based management

- Integrated model tool for improved risk assessment of oil spills, focusing on:
  - Zooplankton (calanus)
  - Fish eggs and larvae
  - Fish stocks
- Two-way coupling of SINMOD (physics and zooplankton), OSCAR (oil spill model) and models for fish larvae and fish stocks



The SYMBIOSES Framework

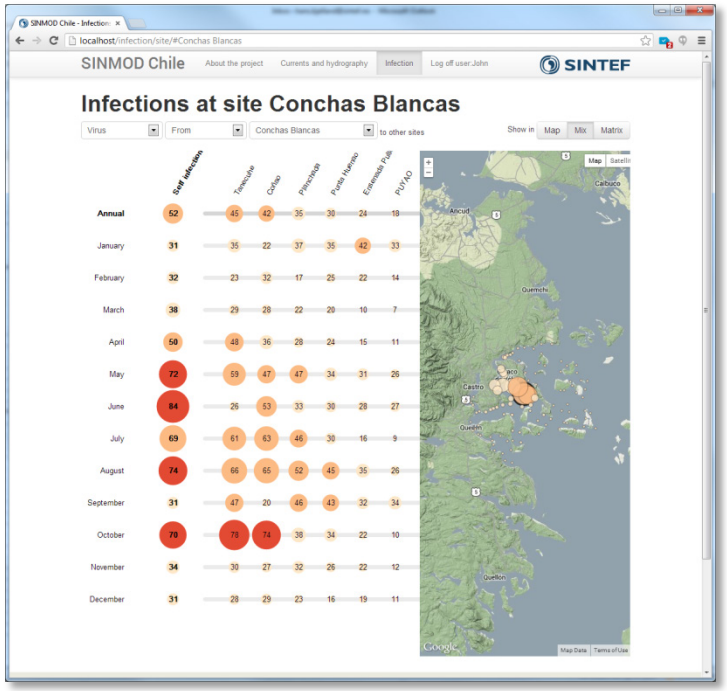
Fishing and petroleum activities are introduced into the model in similar ways, allowing for comparison of the risks and benefits for different environmental outcomes.

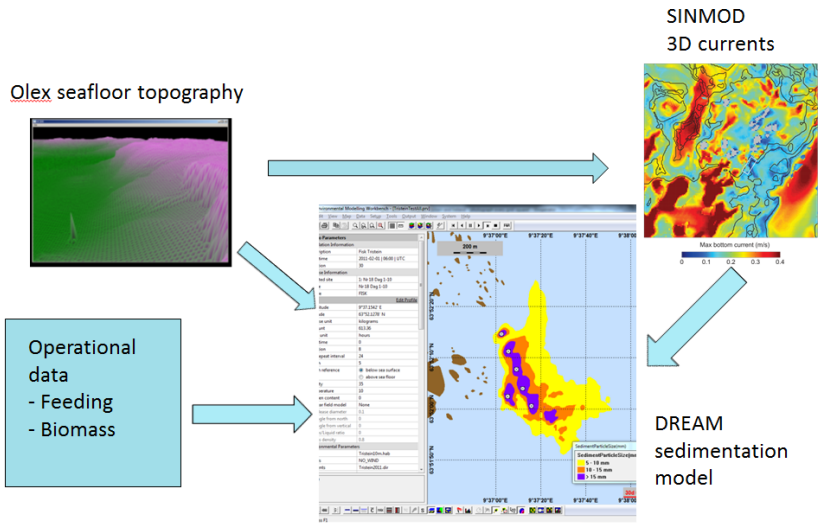


The system generates a range of outputs, from water current fields and plankton distributions to toxicological endpoints and effects, to fisheries parameters.

Aquaculture aplications

- Modelling of waterborne infection risk between aquaculture locations
  - Release and tracking of particles with active vertical behaviour in SINMOD
- Modelling of **sedimentation of organic material** below aquaculture farms
  - Coupling of SINMOD and DREAM





EEA PT02-Call for Proposal

3. ELIGIBLE ACTIVITIES:

For the purpose of this call are eligible proposals of oceanographic campaigns with the aim to:

- Work on gathering scientific **data** and information already available about the selected areas
- Cartography and characterization of seabed and respective habitats in MSFD critical areas, as established in the definition of "MSFD critical area" for the purpose of this Call
- **Data** compilation related to descriptors relevant to MSFD, as established in the definition of "MSFD critical area" for the purpose of this Call
- Identification of key-species or associations of species as ecological indicators
- Identification of the trophic interactions
- **Data** collection and information compilation that allows the assessment of the suitability of the criteria and methodological standards for the assessment of good environmental status in respect of the national marine waters, for each considered descriptor, as defined in the Decision of the Commission 2010/477/UE Characterization of the interaction, and resulting effects, between the deep sea ecosystems and the overlying water column ecosystems
- The collection of any other **data** that can be considered important to the accomplishment of deliverables requested on this Call.

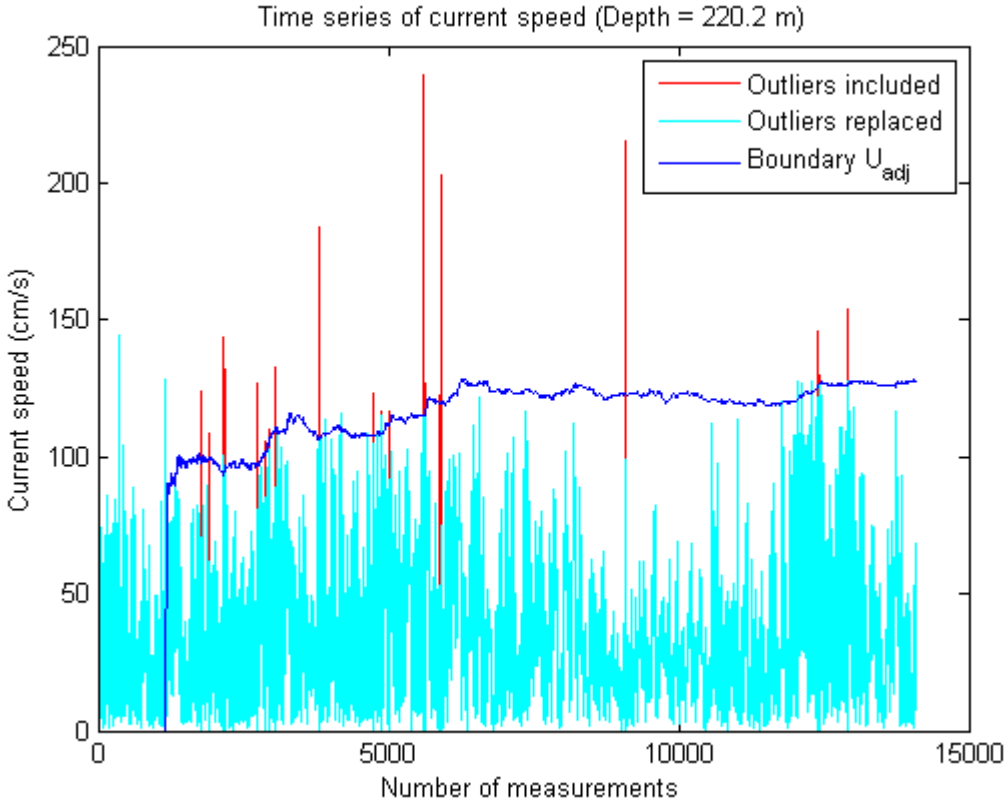
CHALLENGES: Environmental data collections

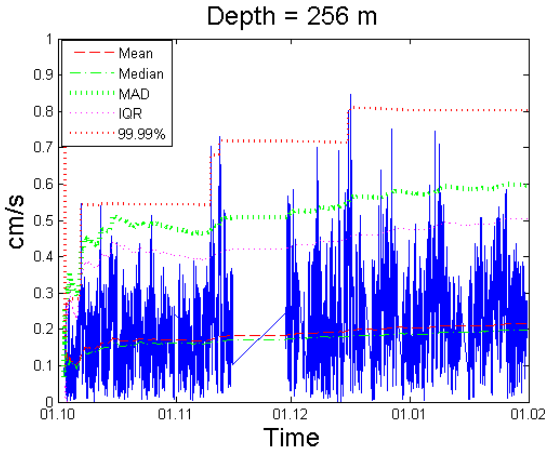
- Quality control of the data
- Filling-in of missing values
- Mixing of data from various sources (buoys, models, satellites,…)
- Assimilation
- Validation and verification of models
- Enhanced statistical analysis
- Stochastic modelling and simulation

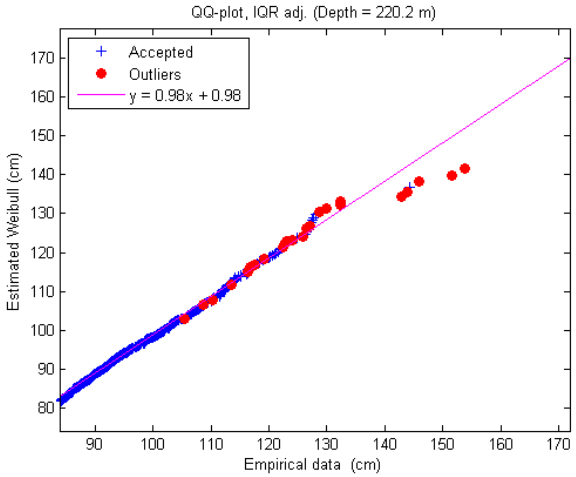
- Compilation of data collections statistics
- Electronic Atlases

Technology for a better society

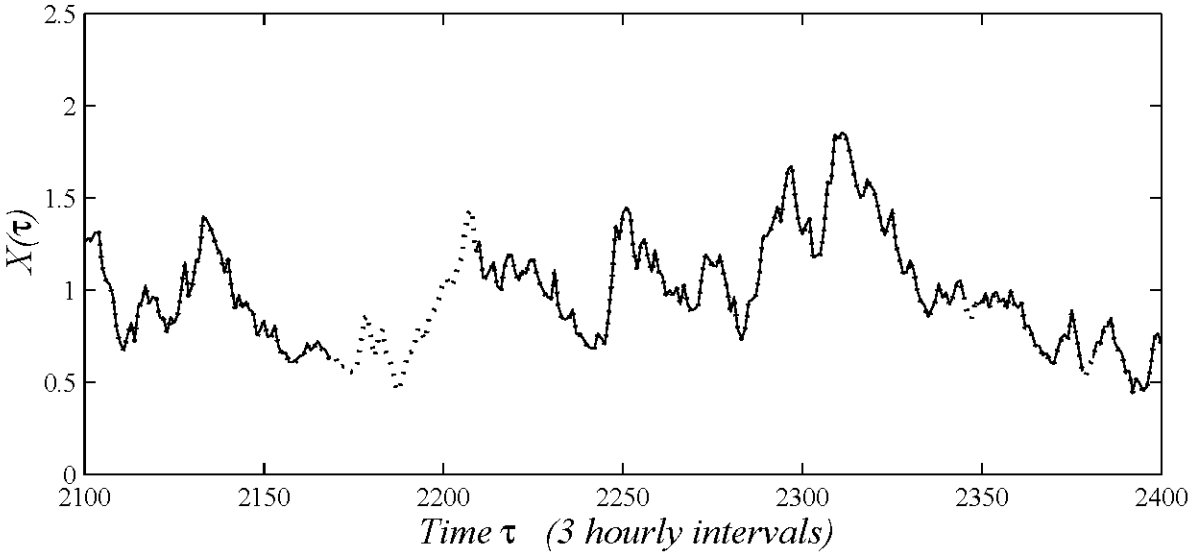
CHALLENGES: Quality control of the data

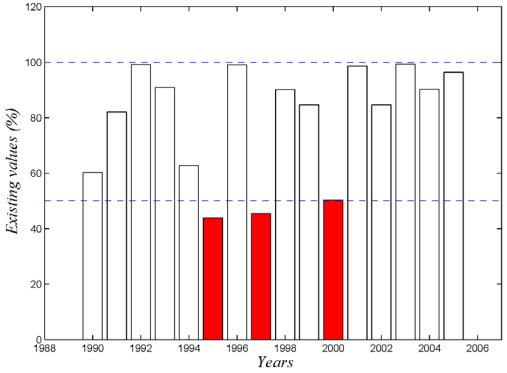


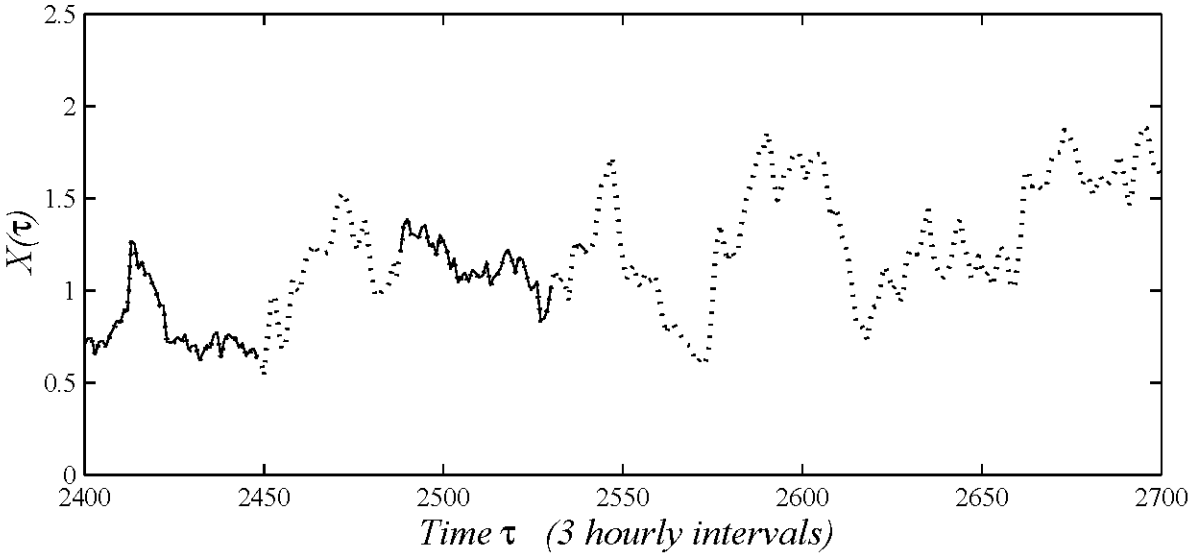


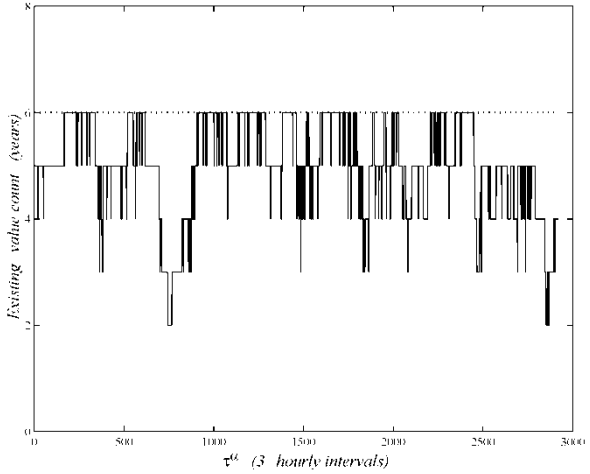


CHALLENGES: Filling-in of missing values

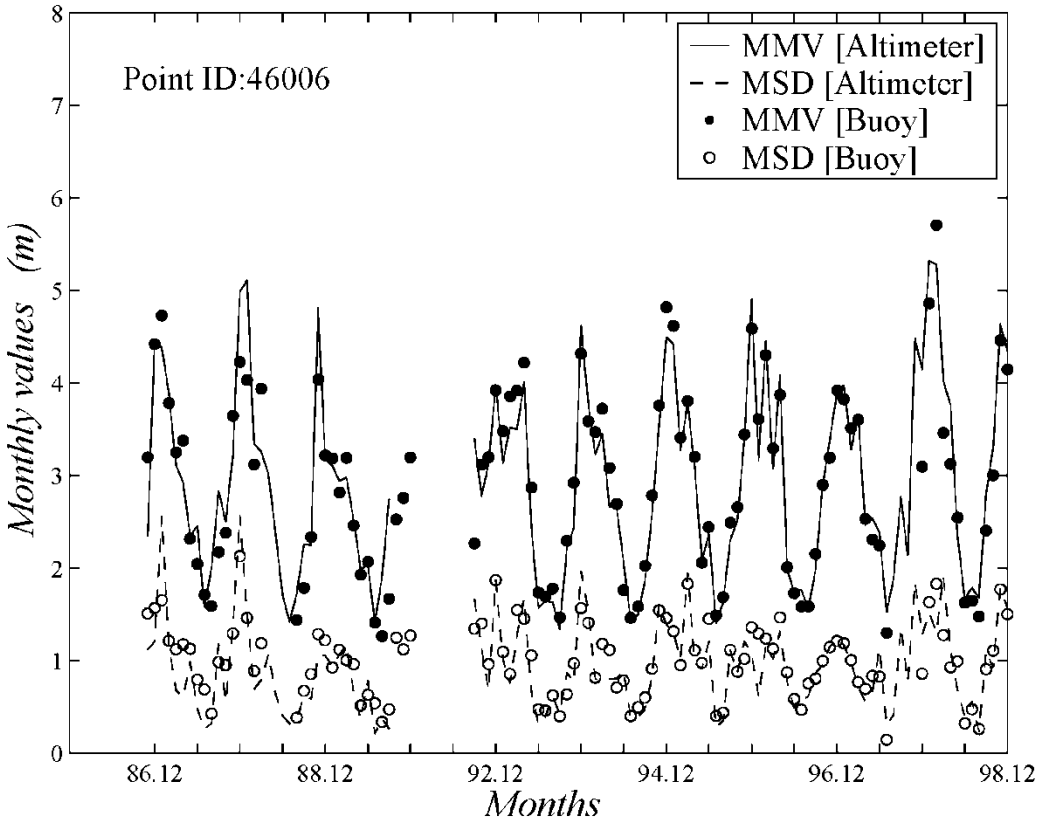


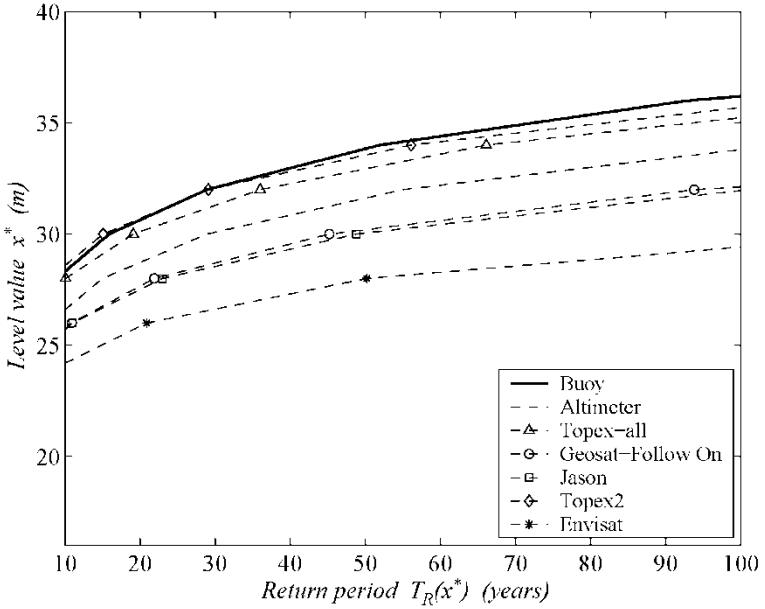






CHALLENGES: Mixing of data from various sources





$$Y(t) = m(t) + s(t)\,W(t)$$

Sattelite data

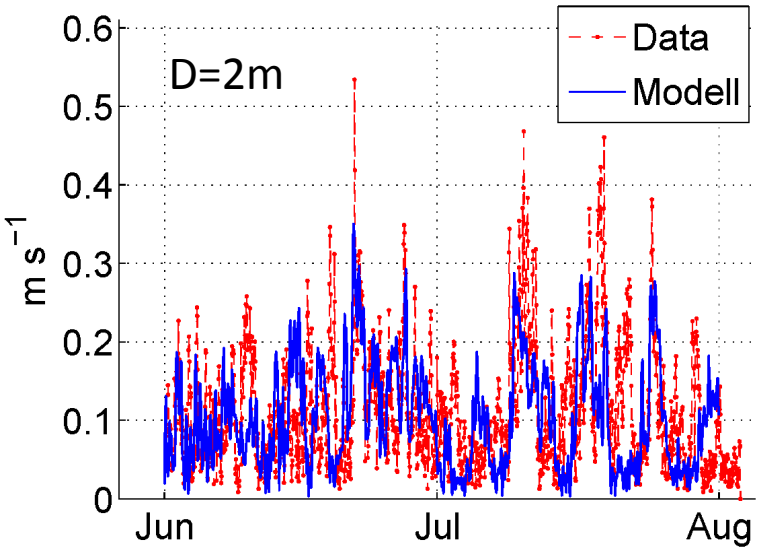
Buoy or Model data

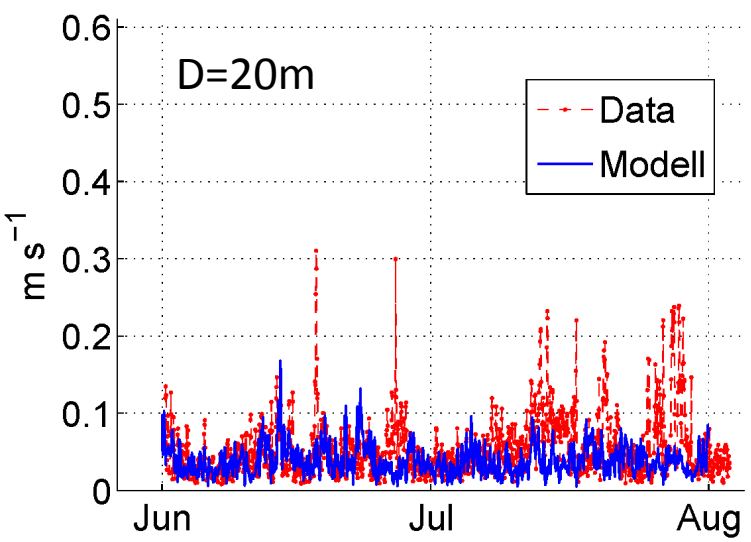
CHALLENGES: Data Assimilation

Current modelling: Ocean models do well at predicting tidal currents, but not at residual currents. This is due to chaotic dynamics, and not likely to change in the near future

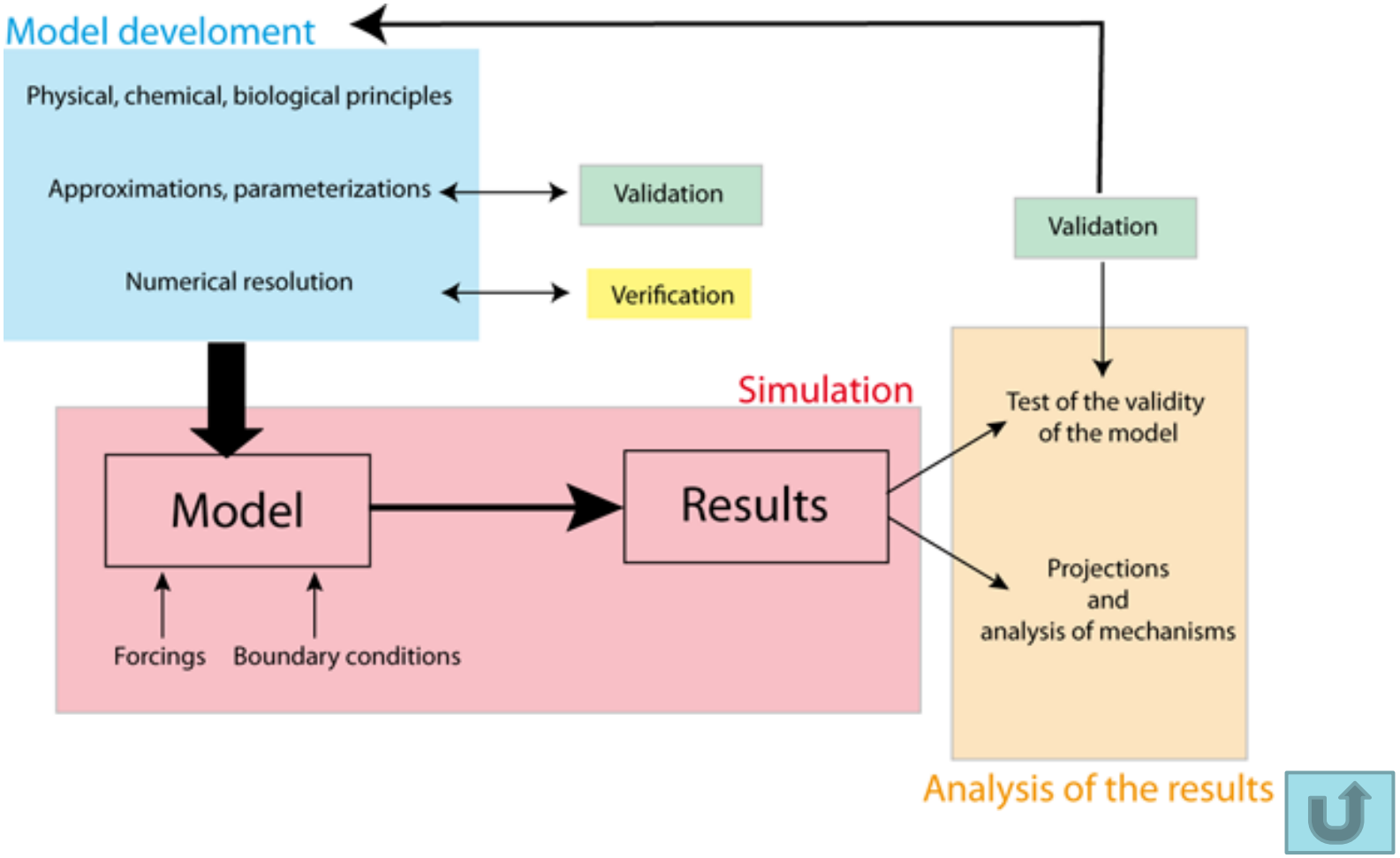
Our best chance to address the problem is by **assimilating measurements**:

- Improved model state for the past and present
- Better initial values for predicting future state

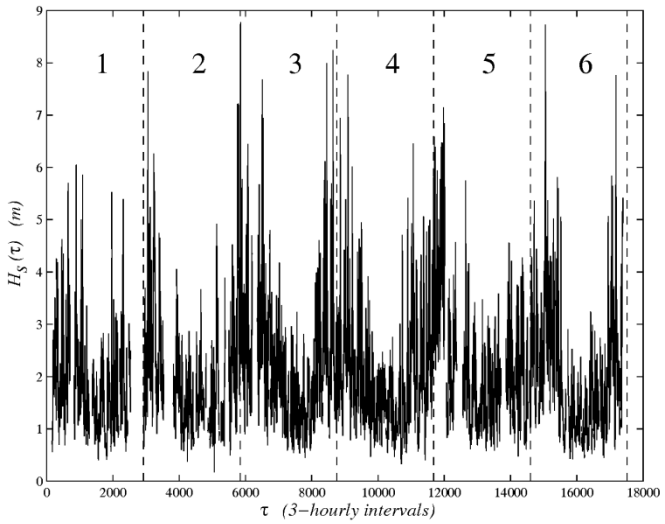


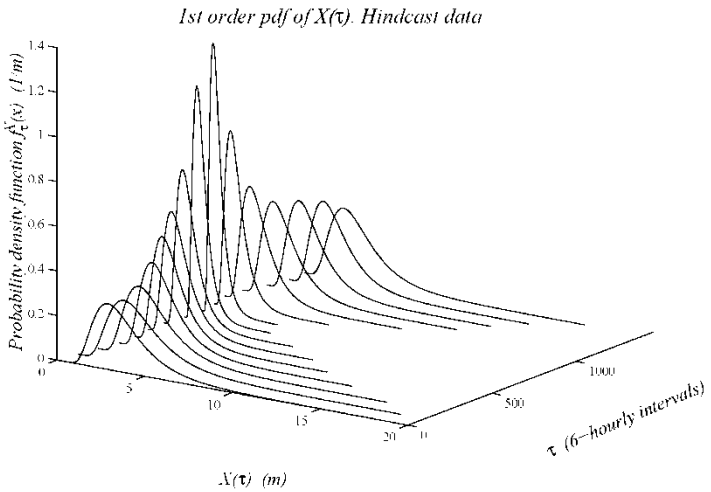


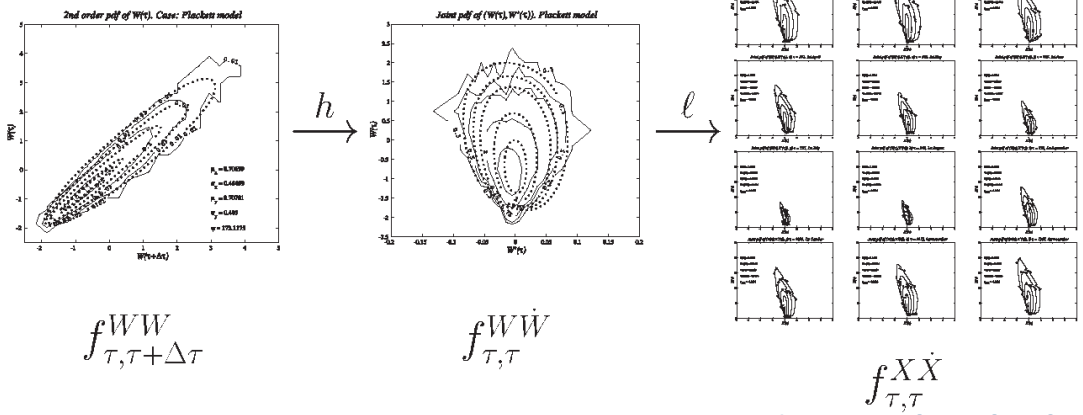
CHALLENGES: Validation and verification of models



CHALLENGES: Enhanced statistical analysis

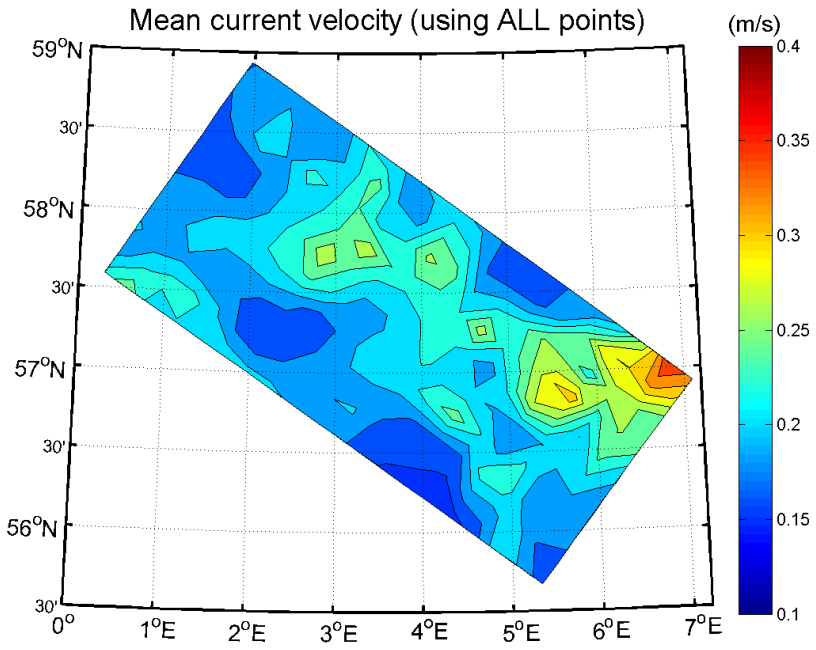




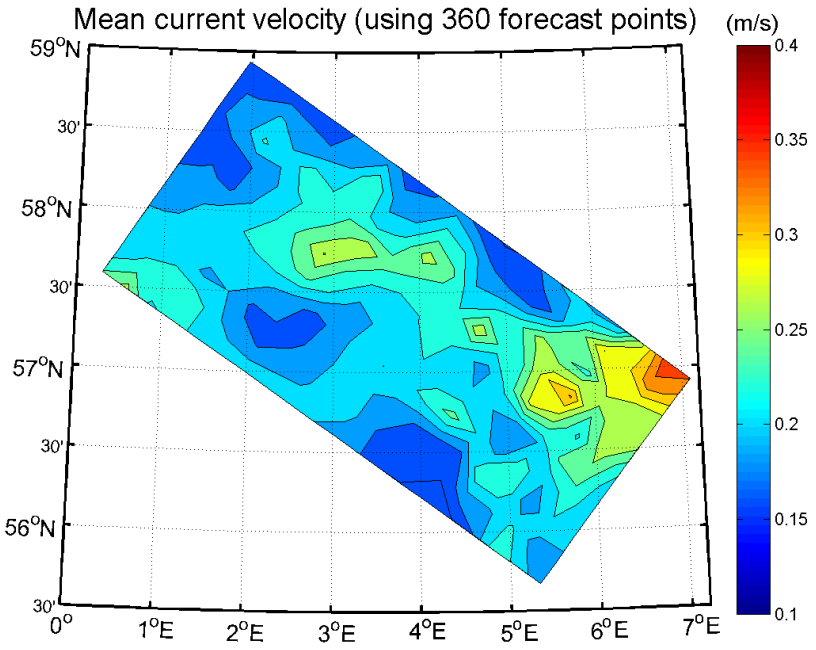


Nonstationary time series and probability analysis

CHALLENGES: Stochastic modelling and simulation



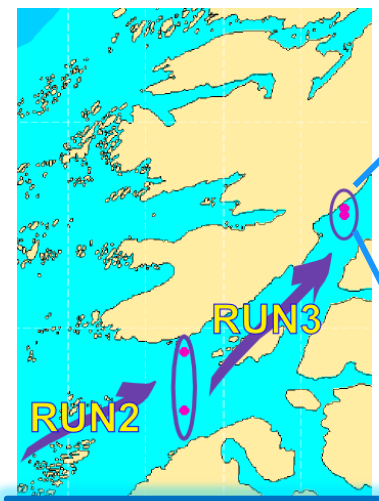
(a) Actual field (15 618 points)

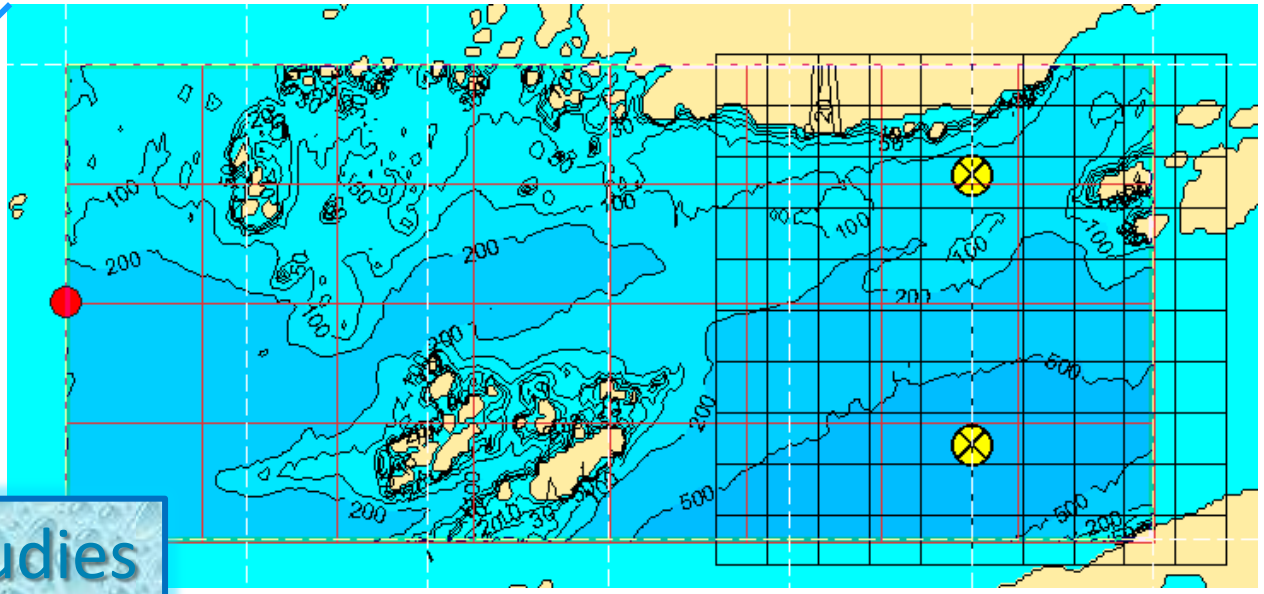


(b) Forecasted field (360 points)

Fuzzy time series forecasting

CHALLENGES: Electronic Atlases. Compilation of statistics





Wave climate studies