Task 5.3: New current design and forecast data

Jesper Sandvig Mariegaard
DHI

LOTUS Final meeting
Brussels, February 4th, 2016

Objective of Task 5.3

Develop and demonstrate a new data assimilation approach in which Level 2 altimeter data are directly assimilated into a high-resolution ocean model

Activities

- Development of data assimilation capabilities in DHI's flexible mesh marine models MIKE 21/3 FM for assimilation of along-track satellite altimetry
- Processed altimeter data of Sea Level Anomaly (SLA) from the SAR mode of CryoSat-2 for the NE Atlantic and North Adriatic Sea were provided by CLS
- Comparison of MIKE 21/3 FM model simulation data and altimeter data of SLA for the NE Atlantic and North Adriatic Sea
- Demonstration of assimilation of altimeter data of SLA for the North Adriatic Sea

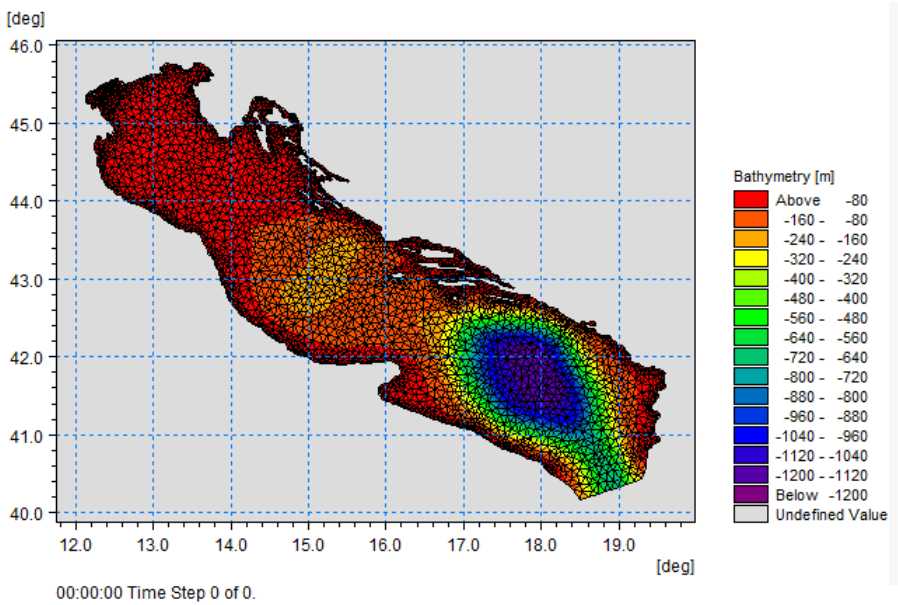
© DHI

Marine models in MIKE Powered by DHI

© DHI

MIKE 21 Hydrodynamic model

- Tidal flow
- Storm surges
- Forcing driven:
  - Wind
  - Water level at open boundaries
- Large models $n \approx 10^5 - 10^8$



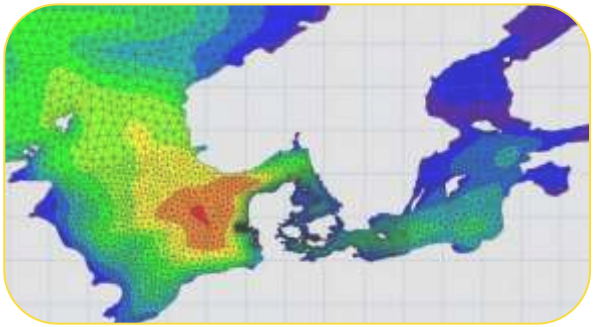
© DHI

Data assimilation in MIKE 21/3

Jacob Tornfeldt Sørensen

Data assimilation (DA): improving model prediction with observations

- Development started in 1999 in MIKE 21/3 classic
- Sequential DA with Ensemble Kalman filter (EnKF)
- Mostly assimilation of tide gauge station data
- Examples of operational DA models
  - NE Atlantic Hindcast/Forecast
  - Great Lakes Forecast
  - Caspian Sea Forecast



- Ensemble: pertubate model through model errors on forcings
- EnKF update: linear combination of ensemble members

© DHI

FM **DA** Module before 2015

- Few fixed positioned tide gauge stations
- Sequential algorithm – one station at a time (Andersson&Andersson)
- Regularization
  - Error covariance temporal smoothing
  - Error covariance localization

© DHI

New developments in FM DA Module

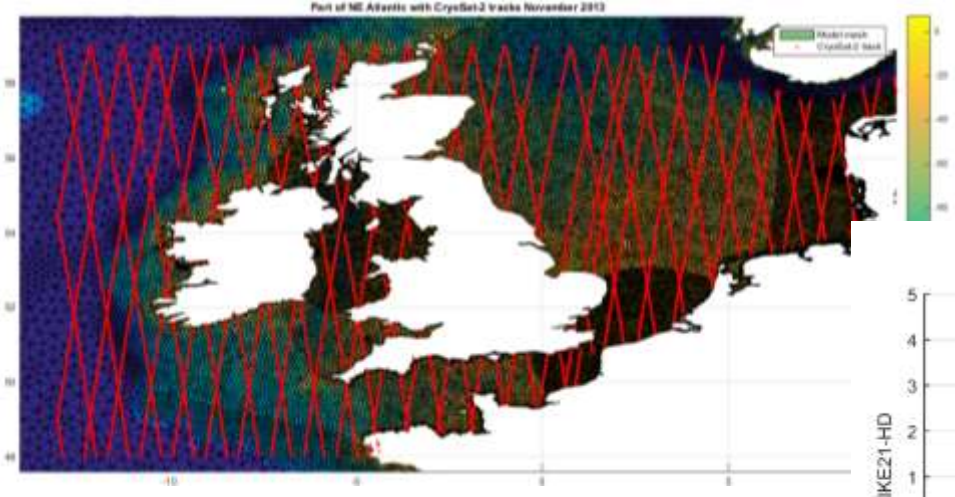
- New data structures and organization to allow changing positions and number of observations
- Implementation of ETKF and DEnKF (inspired by code by P. Sakov)
- Localization by Local Analysis
- Reading and processing track data observations (point set)
- EnOI (in progress)
- Other: Several error formulations pr model error, improved data structures (abstraction), improved IO, diagnostics, inflation, observation operator interpolation

© DHI

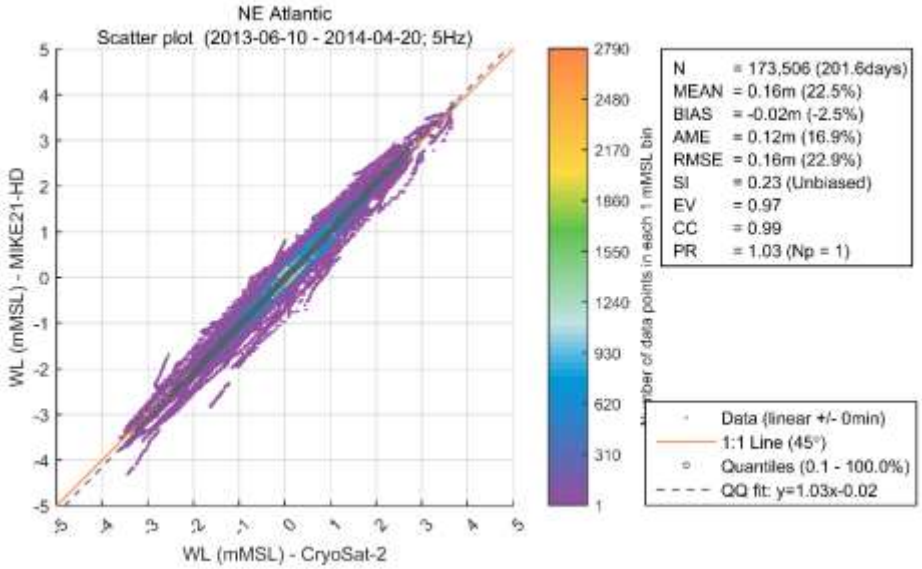
Assimilating along track satellite altimetry

© DHI

Along track altimetry observations(1)



- Raw data errors: st dev + correlation in time (along track)
- Errors estimated against 35 year hindcast NorthSea model

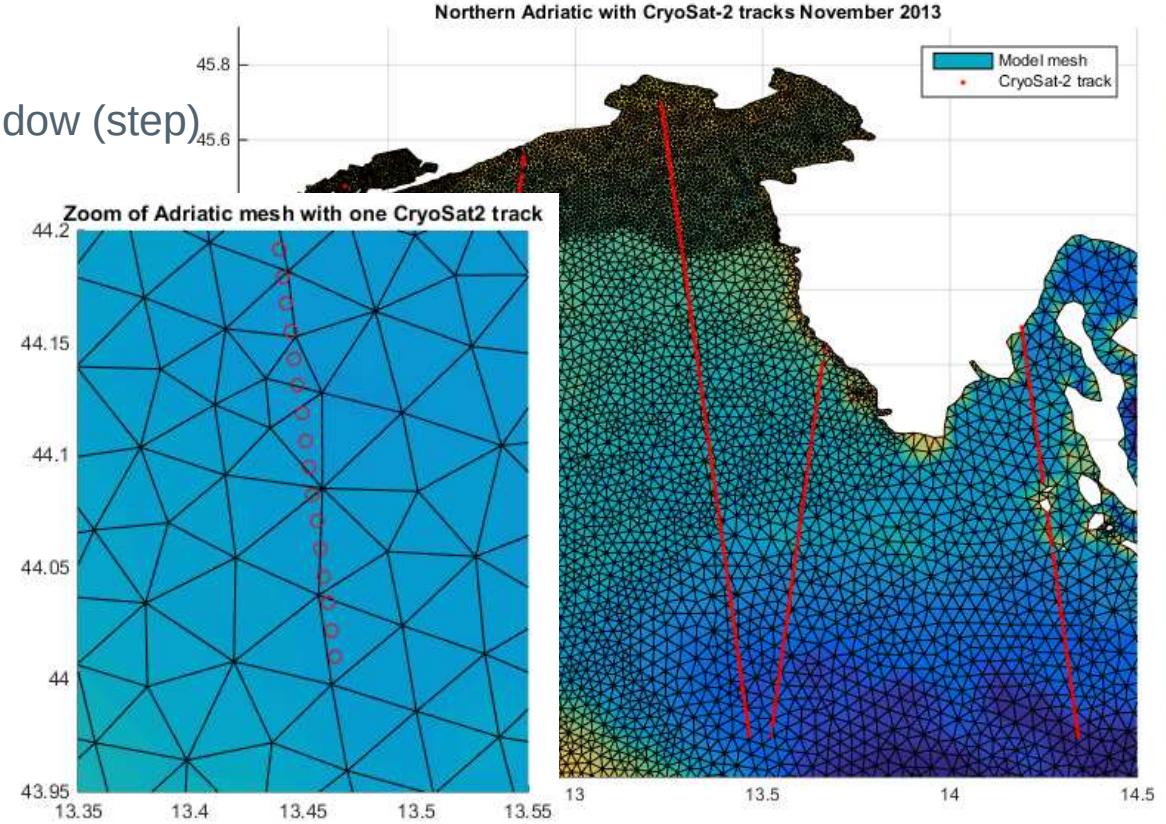


© DHI

Along track altimetry observations(2)

- Super observations
  - one pr element pr time window (step)
  - Construct local R
  - Adjusted st dev by local R
- Construct R pr model step
  - (several super elements)

Validation tests performed with synthetic data



© DHI

Case study: Adriatic Sea

© DHI

Adriatic Sea case

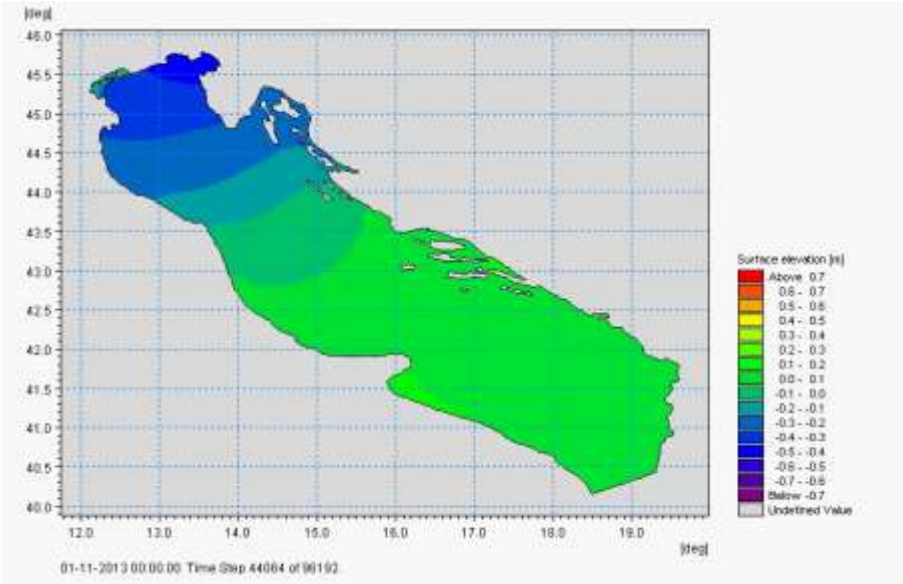
HD 2d

- Approx 5000 elements
- 11 months (June 2013 – May 2014)

DA

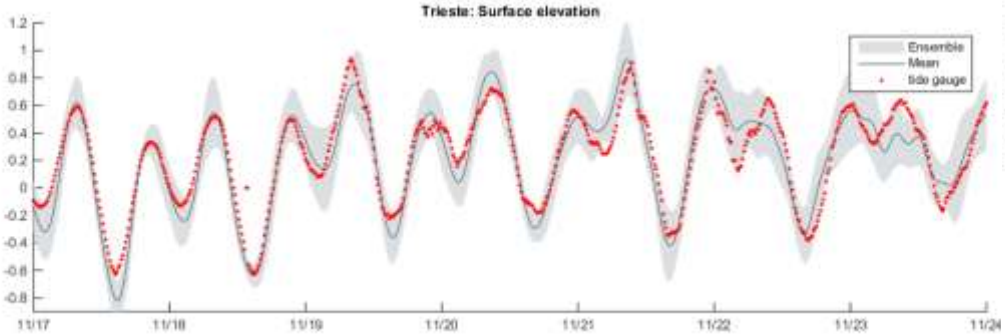
- 10 ensemble members
- Model errors
  - Wind
  - Water level on open boundary

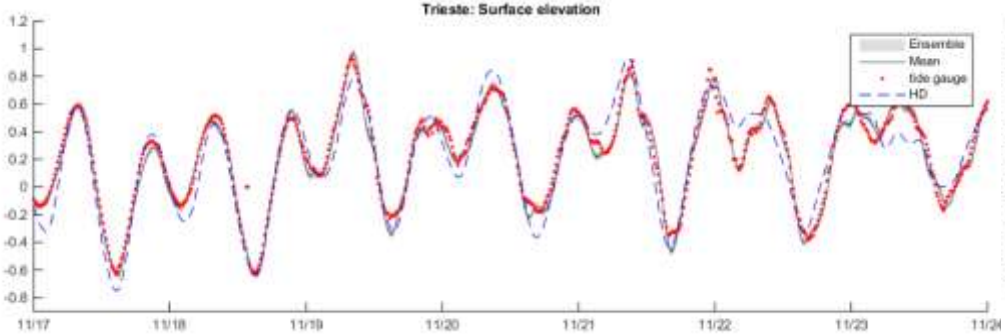
1) DA with 2 tide gauge stations
2) DA with only track data
3) DA with 2 stations and tracks

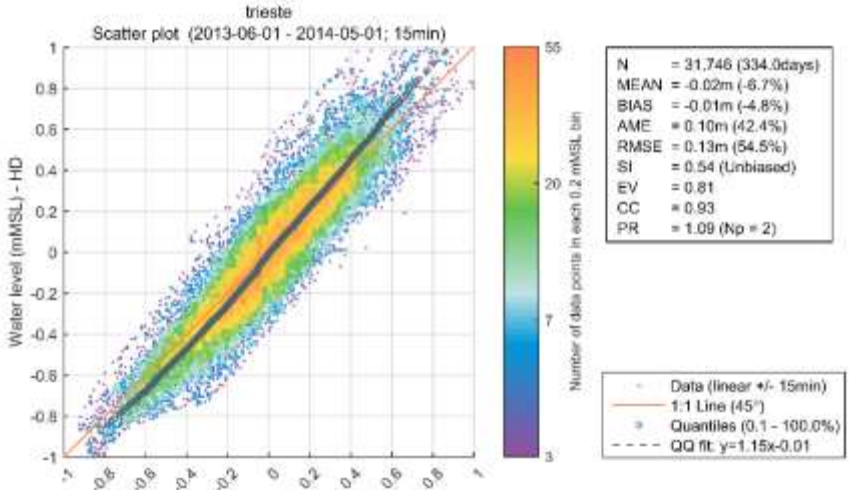


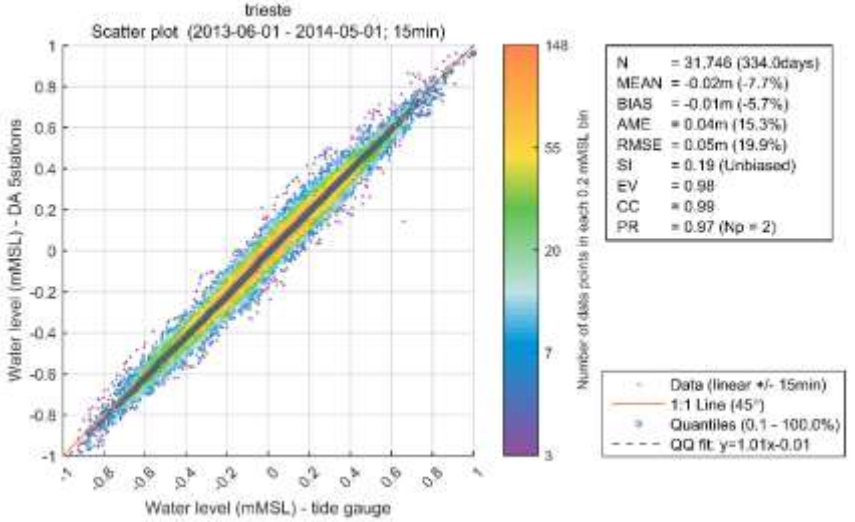
© DHI

No-DA and DA with tide gauges







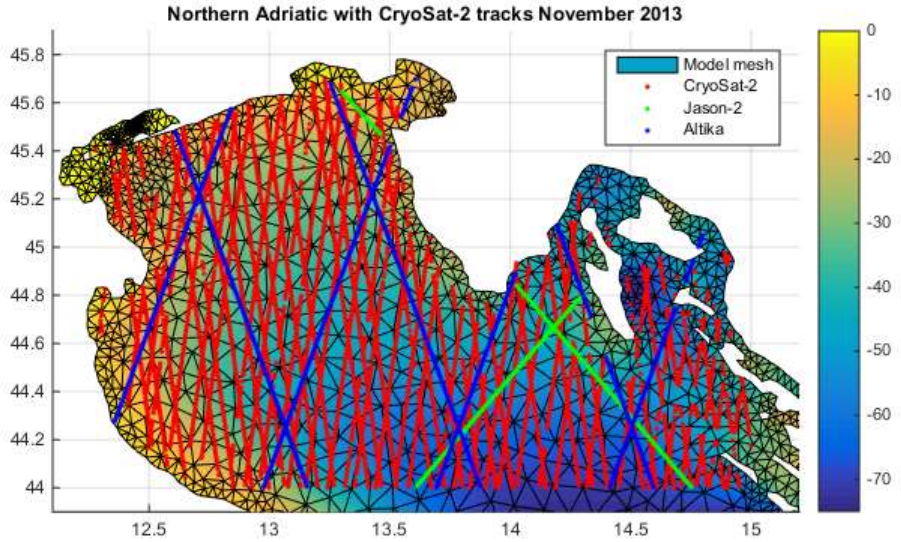


© DHI

DA with along track altimetry

Altimeter data

- Less than one minute of data a day
- Average passing frequency of 1.5 days
- Error: temporal correlation: 25 sec
- Error: st. dev. 5 cm



RMSE in cm

	HD (no DA)	DA 2stations	DA 3 tracks	DA 2st.+3trck
Trieste (DA)	12.8	2.5	14.9	2.5
Venezia	11.5	4.0	13.0	4.0
Ravenna (DA)	12.4	7.6	13.6	7.7
Ancona	9.5	3.4	10.2	3.4

© DHI

Conclusions

Task 5.3 completed

- Data assimilation in MIKE 21/3 improved and now handles along track altimetry data
  - Includes observation error description with correlated errors
  - Validated with synthetic data

- New data assimilation technique tested in real case: Adriatic Sea
  - Unfortunately too infrequent data to give positive results
  - Will presumably work well on larger areas and with more frequent (Sentinel-3) data

© DHI

Thank you

Jesper Sandvig Mariegaard
jem@dhigroup.com

© DHI