Tide Gauge and Satellite Altimetry integration for Storm Surge prediction.

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DTU Space
National Space Institute

Overview

Satellite altimetry and Test regions

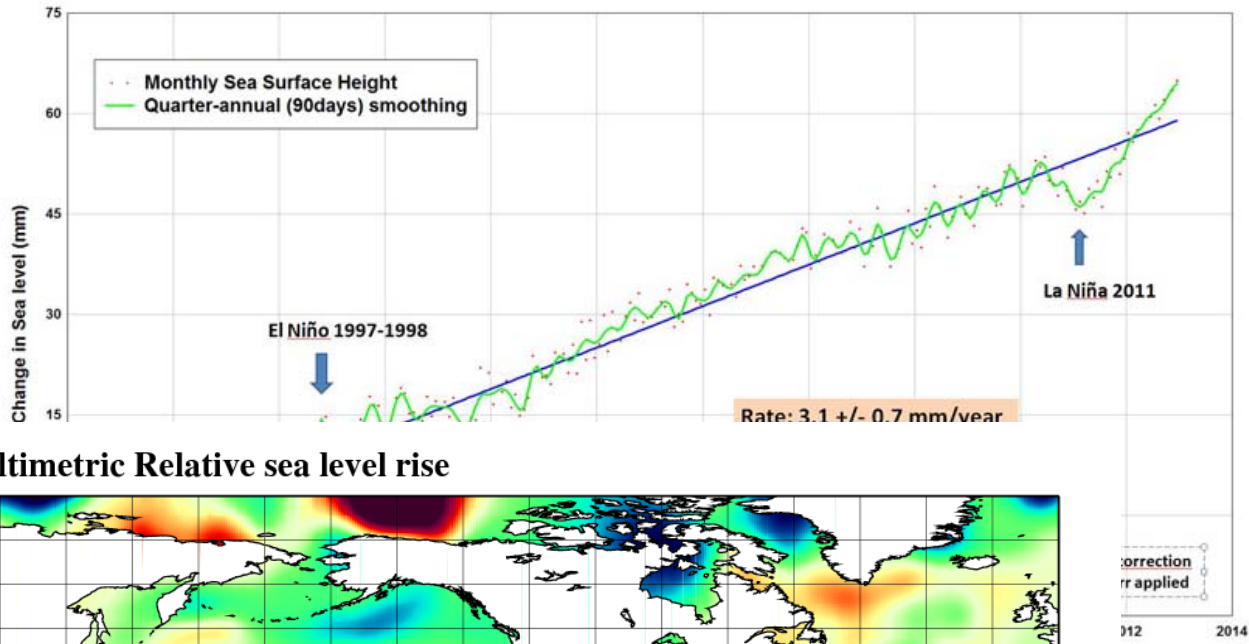
Crital issues:

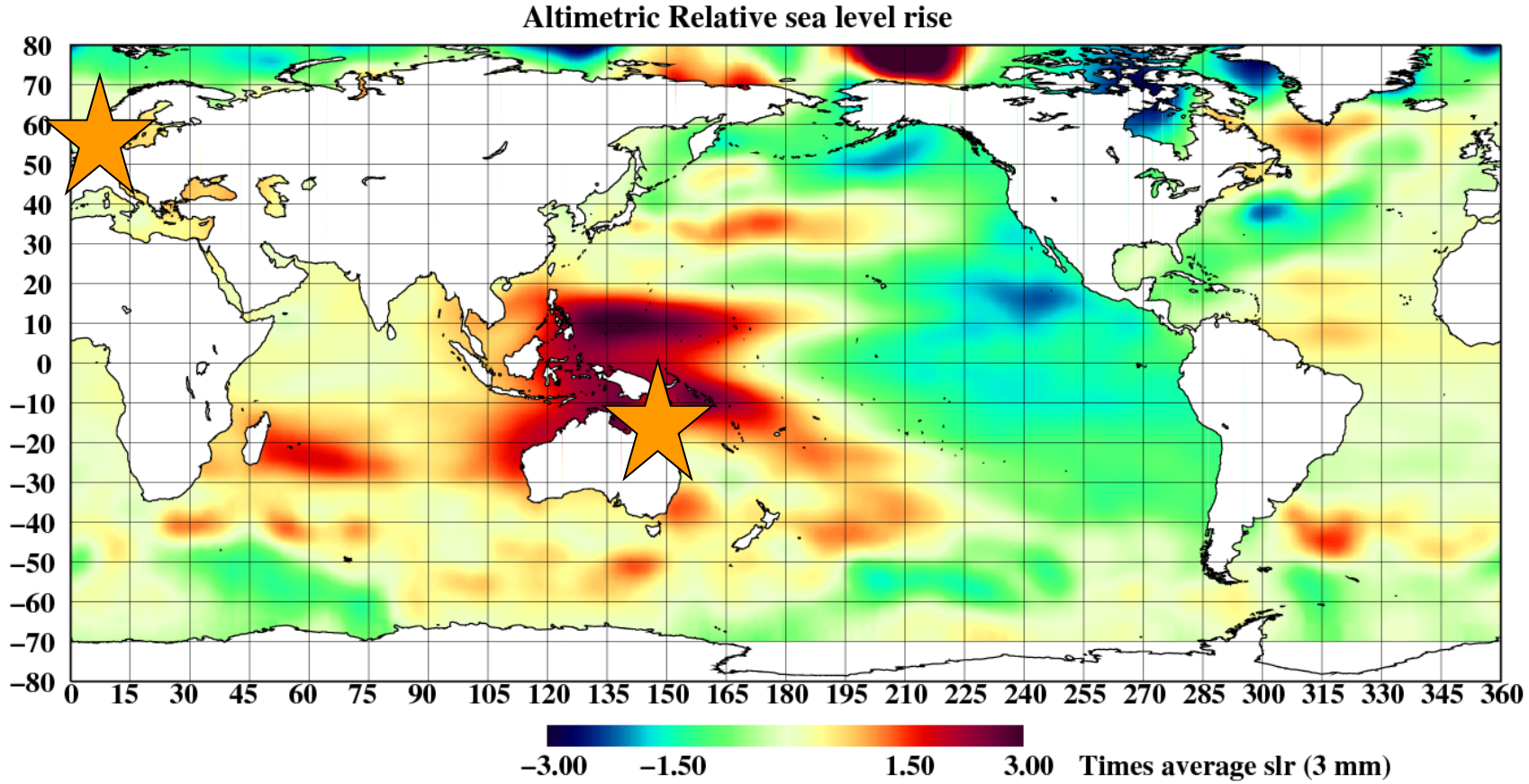
- Spatio-temporal sampling vs surge / cyclone
- Availability and accuracy
- Accuracy degradation (Coastal and rain).
- Reliability of surge capturing
- Importance of residual range corr errors:
  - Ocean tide correction
  - spatio-temporal correlation

- Merging with tide gauges
  - Hindcast / forecast modelling

Conclusions.

Satellite altimetry is well Esabished for linear sea level change





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Test regions: Surges / Cyclones

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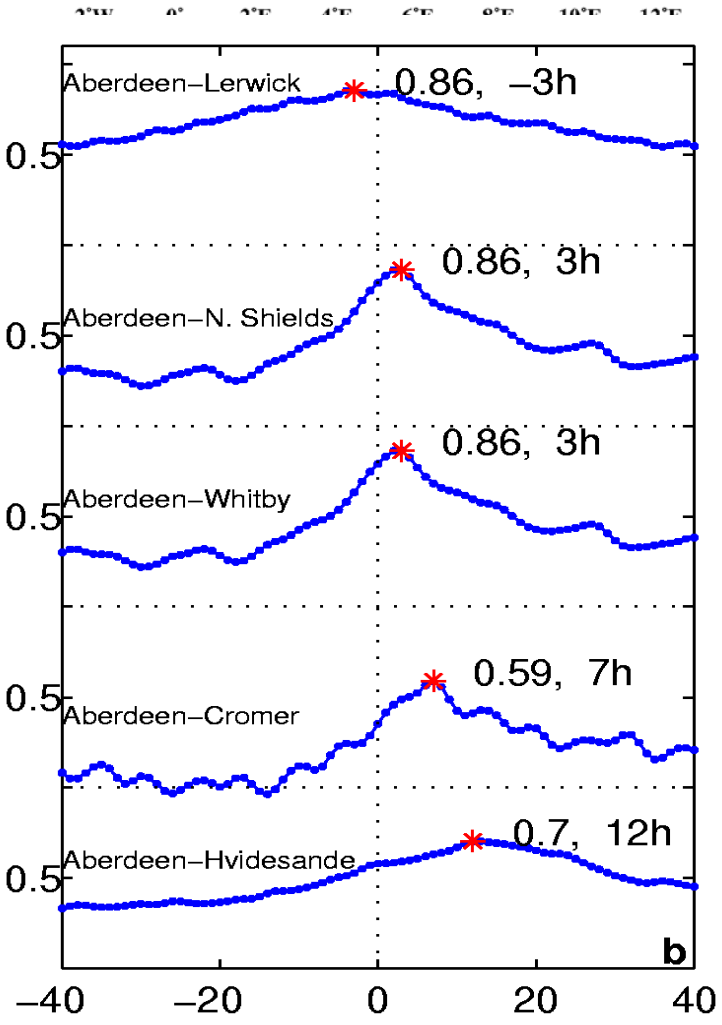
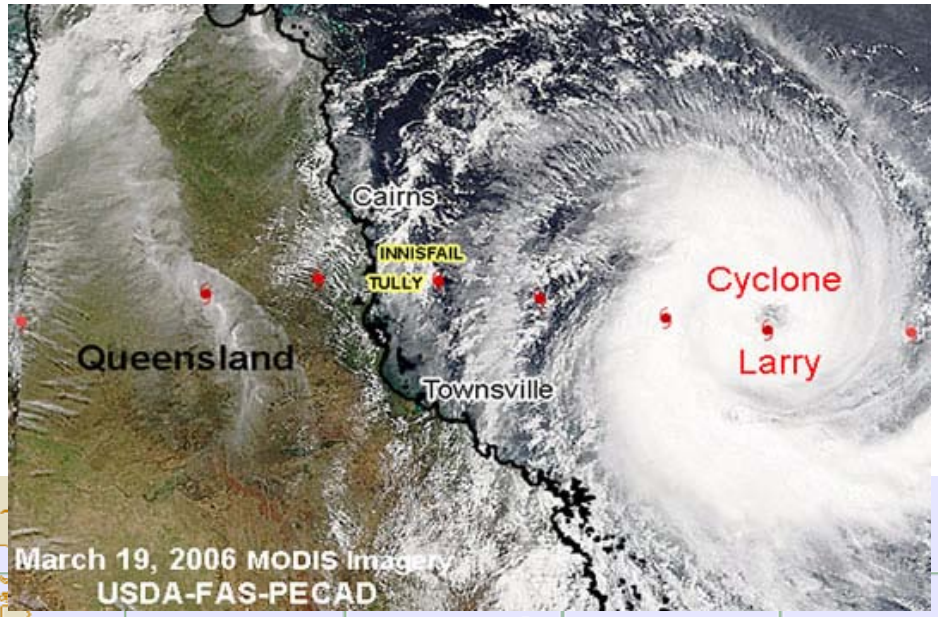
North sea:

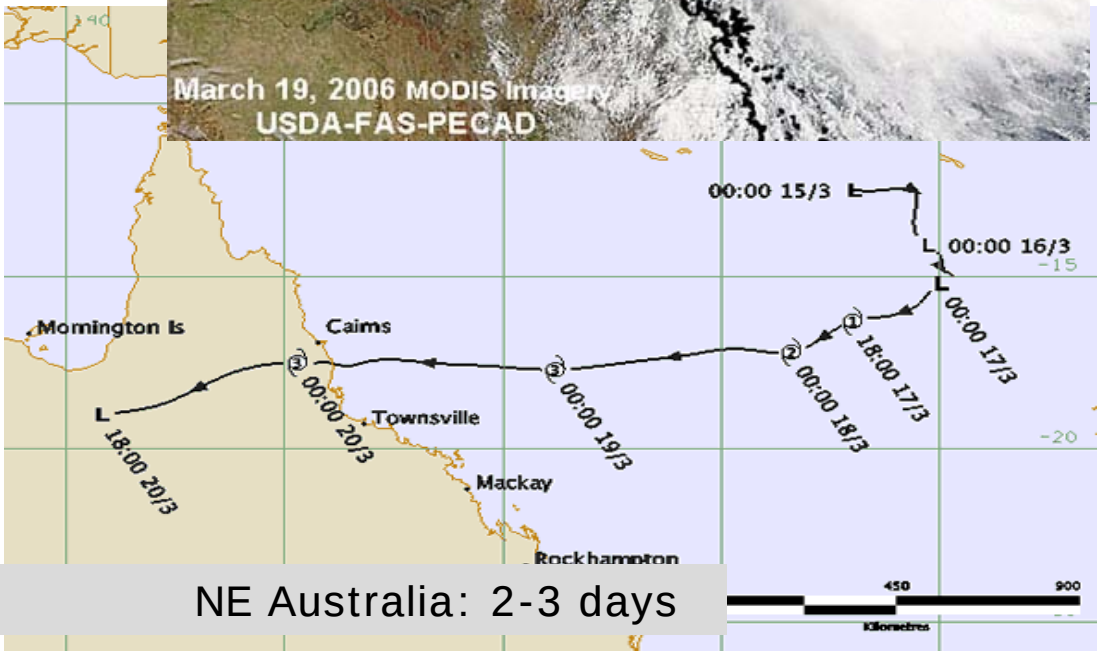
Few mainly external surges



NE Australia / GBR:

Seasonal cyclones (near seasonal)





Time scales: North Sea: 1 day

NE Australia: 2-3 days

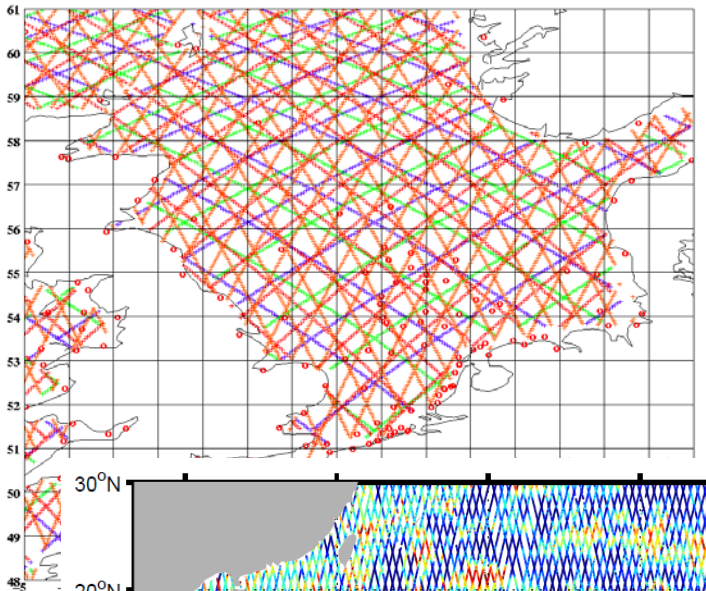
Current Satellite Sampling:

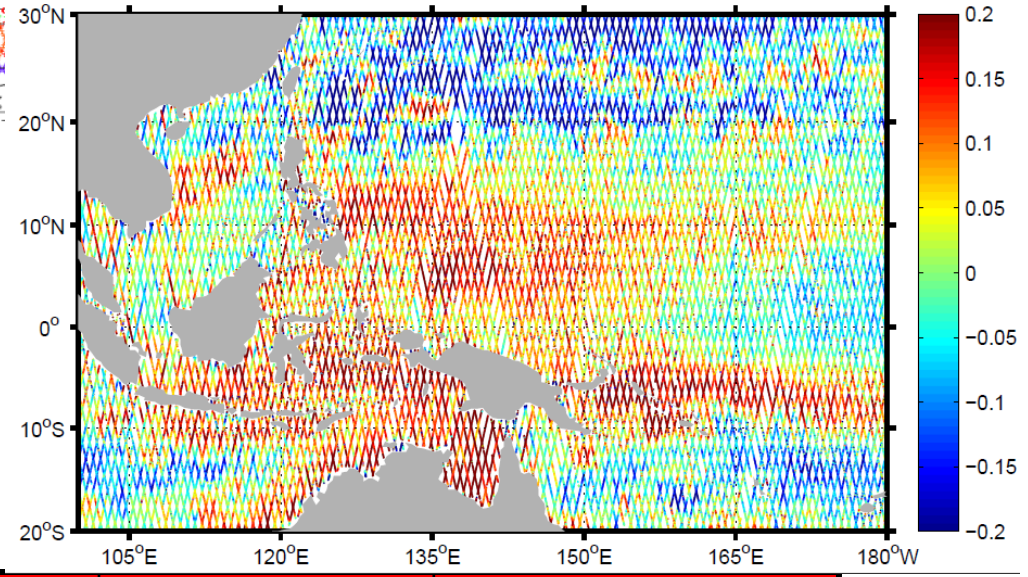
3 ongoing missions

- **Jason-2**
- **Cryosat-2**
- **AltiKa (French-India)***
- ***>10% data affected (not seen).**
- **HY-2 (China)**
- **Sentinel-3 (SAR)**

Near Real time data

- **J2+C2: 4-6 hours**
- **Accurcy: 4-6 cm**





Satellite	Repeat Period	Track spacing	Inclination Coverage
Jason-2	10 days	315 km	66.5°
CryoSat-2	369 days	8 km	92° (+/-88°)
AltiKa	35 days	80 km	98° (+/-82°)

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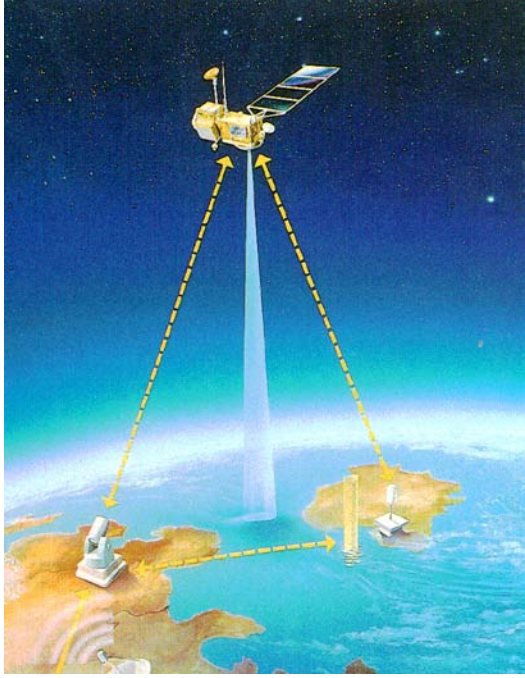
Sea Level and Storm Surges



Critial issues:

- ✓ **Spatio-temporal sampling vs surge/cyclone**
- ✓ **Availability and accuracy**
- ⇒ **Accuracy degradation (Coastal and rain).**
- ⇒ **Reliability of surge capturing**

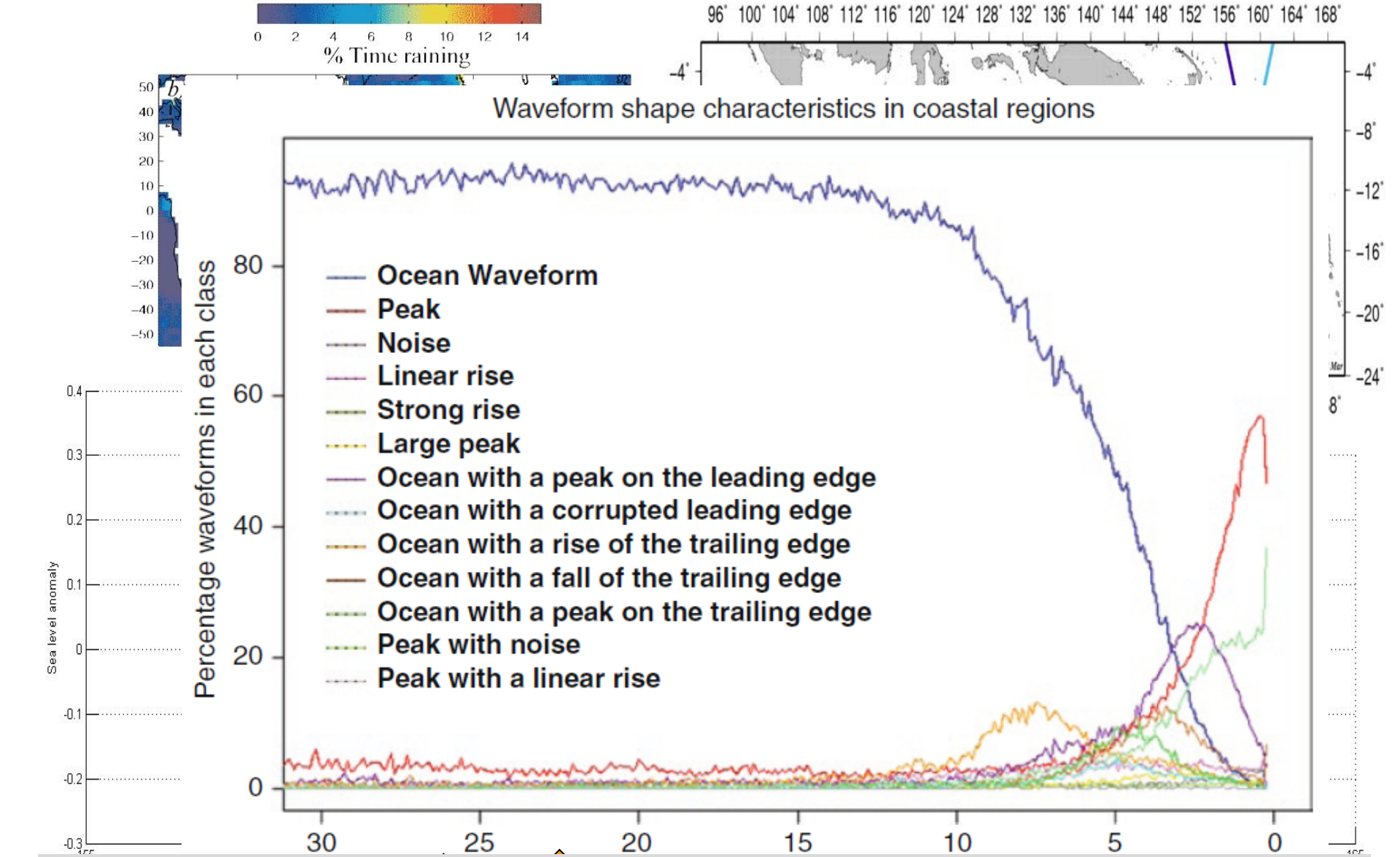
Importance of residual range corr errors:

Ocean tide correction

Merging with tide gauges (spatial temporal correlation)

Hindcast / forecast modelling

Heavy Rain + Coastal problems



Retracking: Simple ICE retracker (Jason) is more noisy but does not have outages

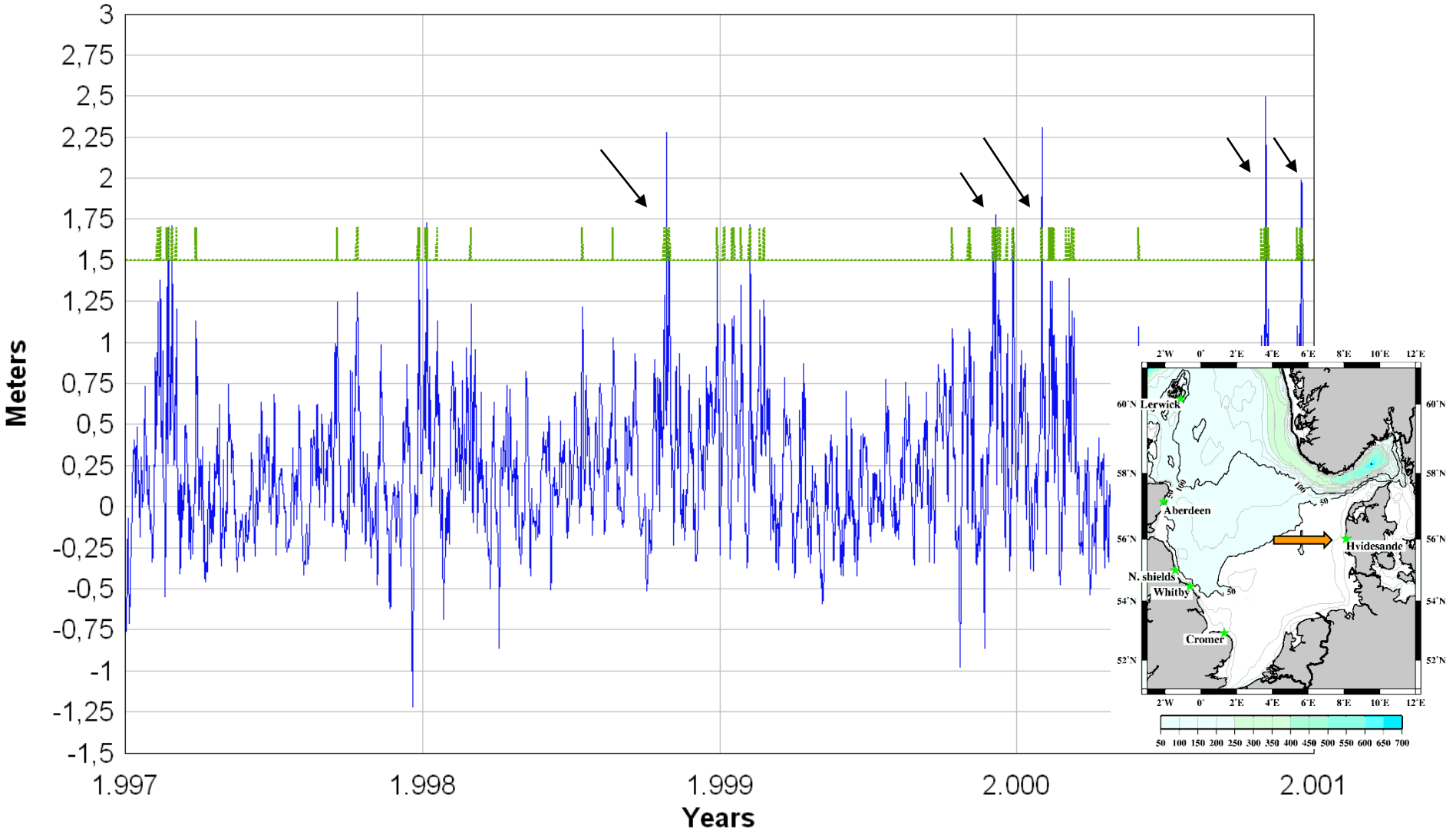
In Situ

Lack of data in North Sea ☺

Last devastating storm surge in Britain – 1953

”Data for validation?”

High Water in Hvide Sande (Denmark)



Simple 2 std. deviation test on "high water"

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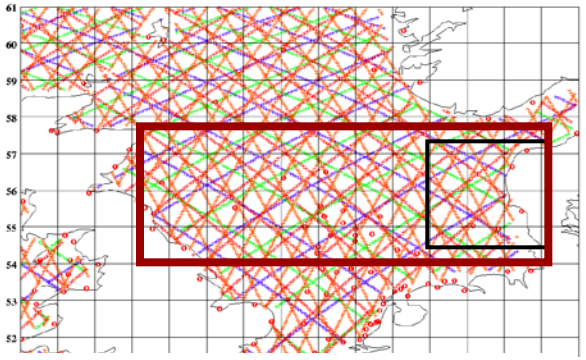
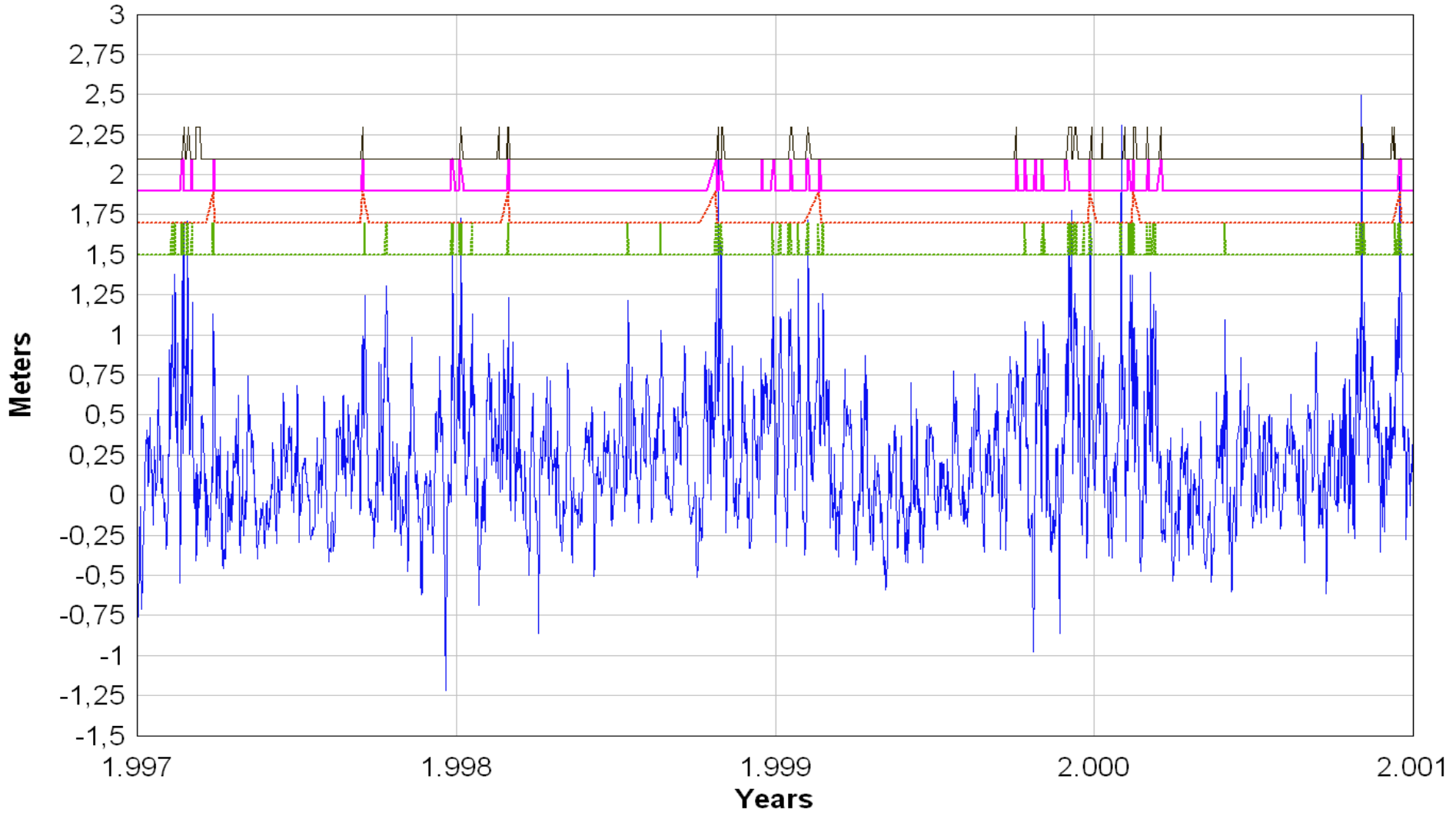
Satellite Obs



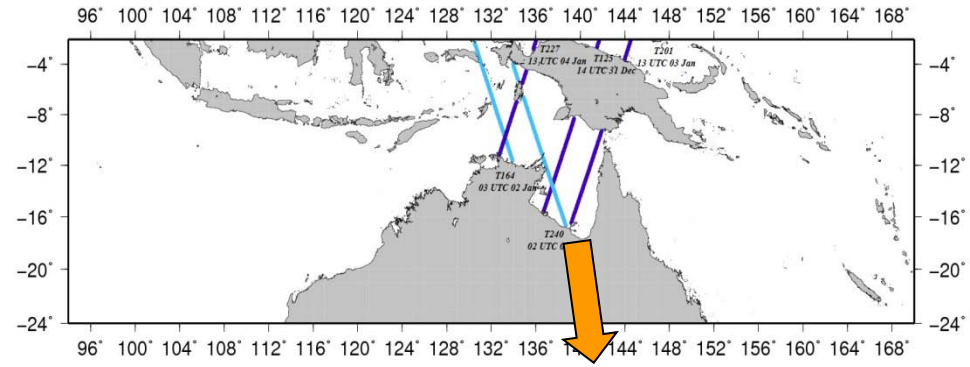
One versus two satellite (TOPEX/ERS-2)

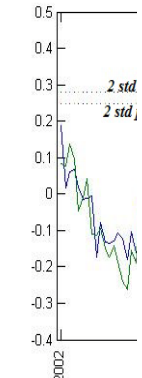
North Sea: Key to succes is two satellites

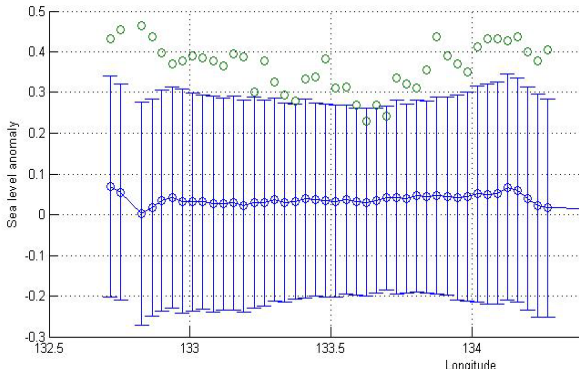


Seasonal Cyclones in NE Australia

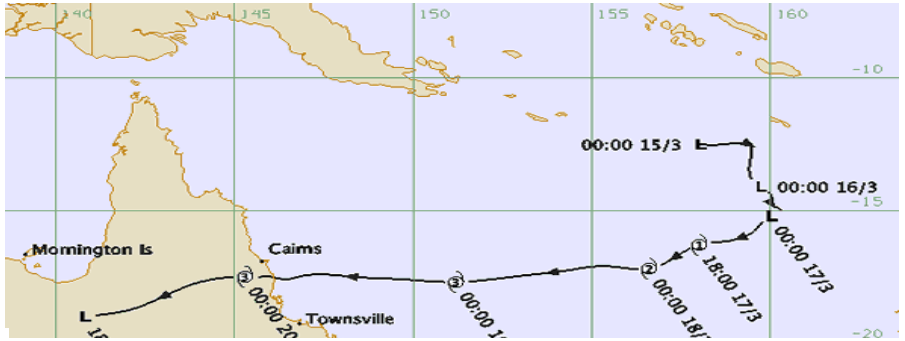
Cyclone Helen (4 January, 2008)

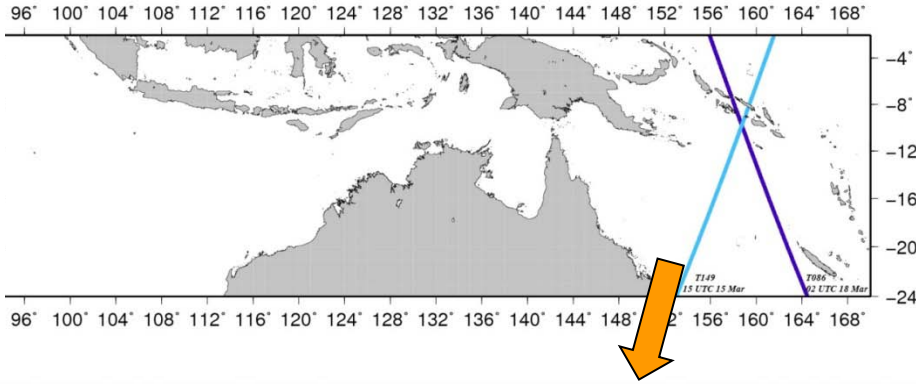


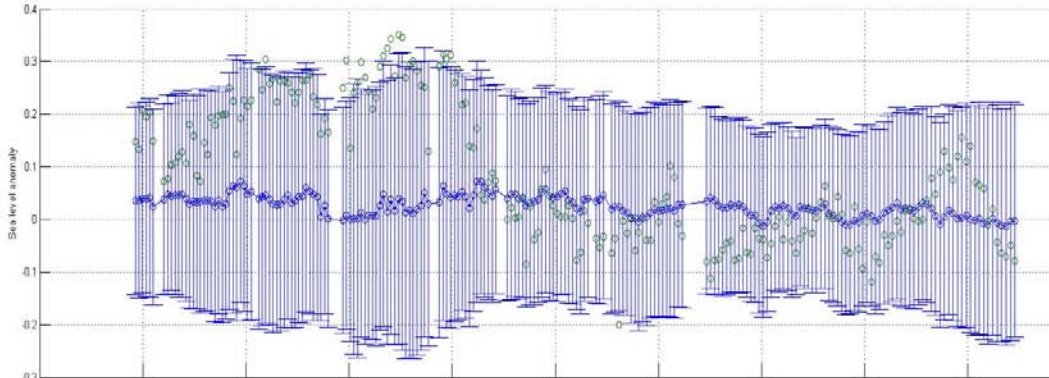




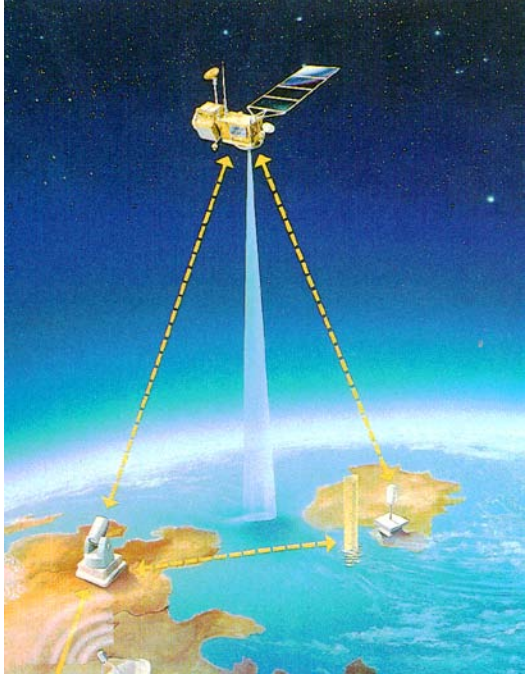
Cyclone Larry (20 March 2006)







Sea Level and Storm Surges



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  - **Spatial temporal correlation**
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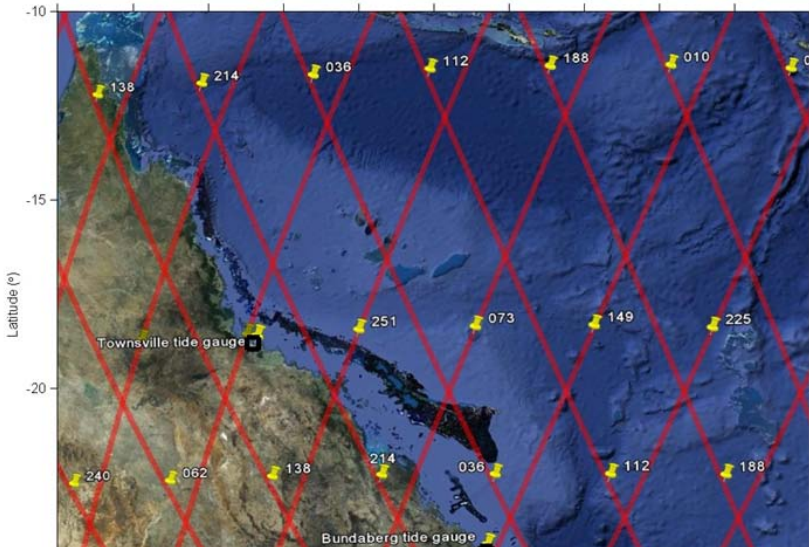
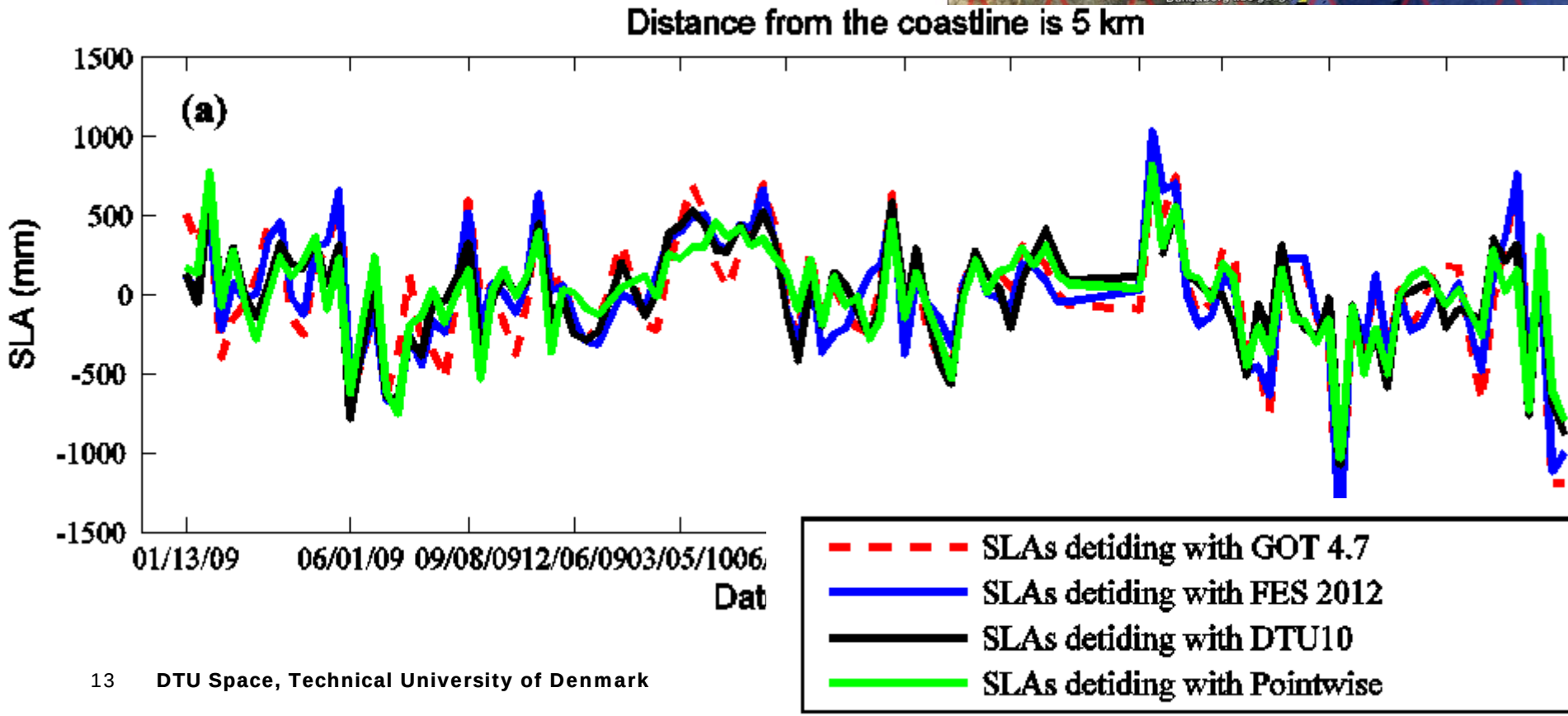
Combining satellite altimetry and tide gauge information

Importance of the de-tiding procedure.

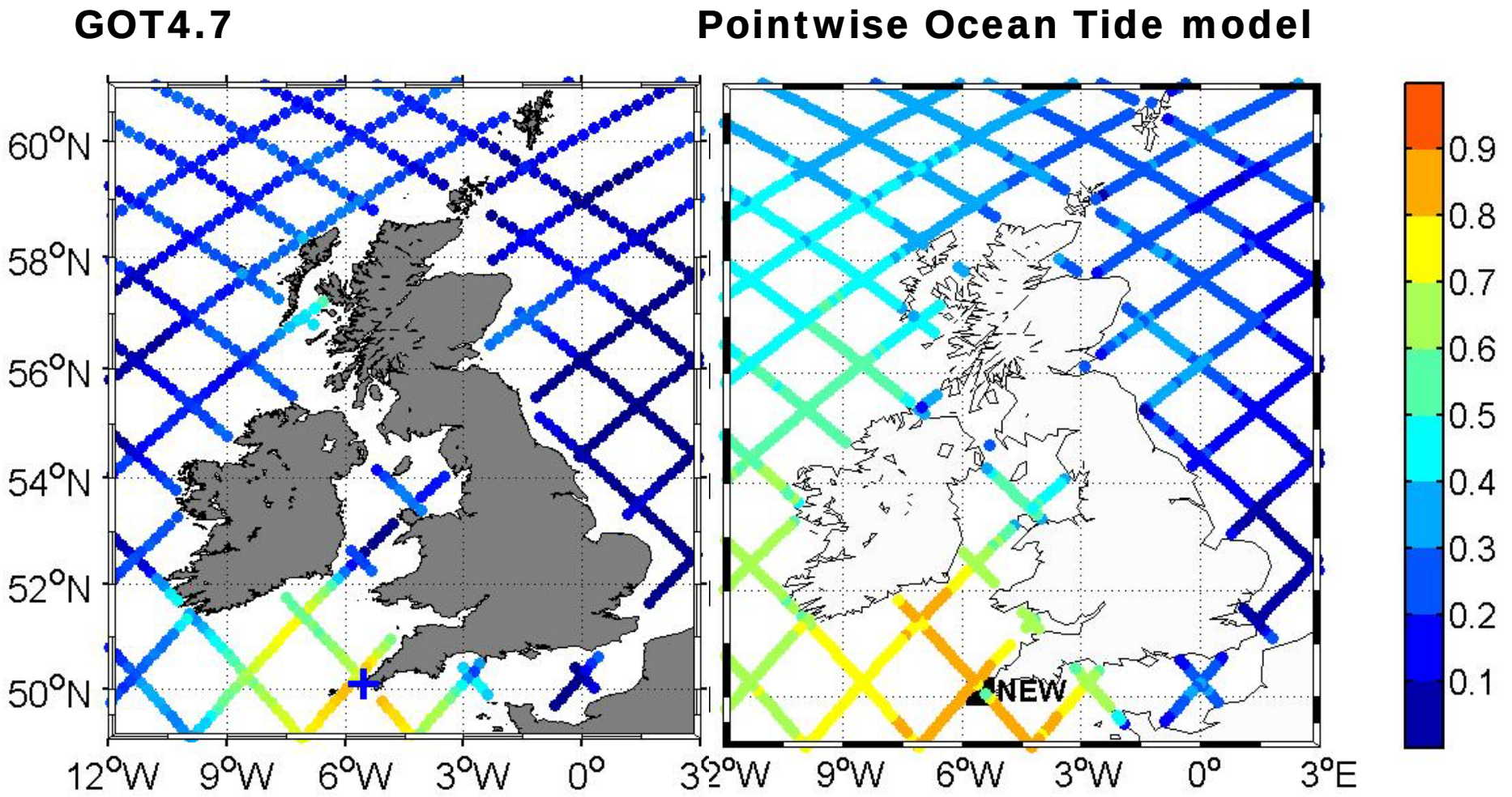
Enhance temporal correlation between

Tide gauge and satellite altimetry.





Spatio-temporal Correlation
Non-tidal (surge) Sea Level variation

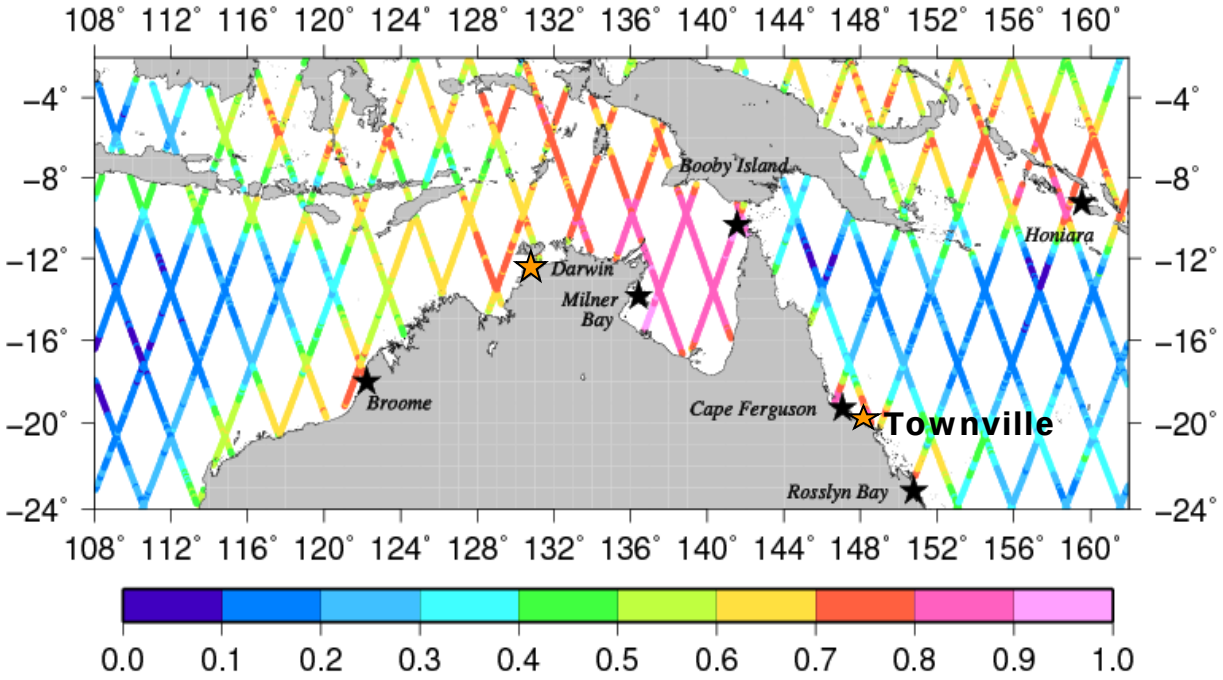


Combing Tide gauges and Altimetry

Use major spatial EOF modes from Jason and 6 tide gauge.

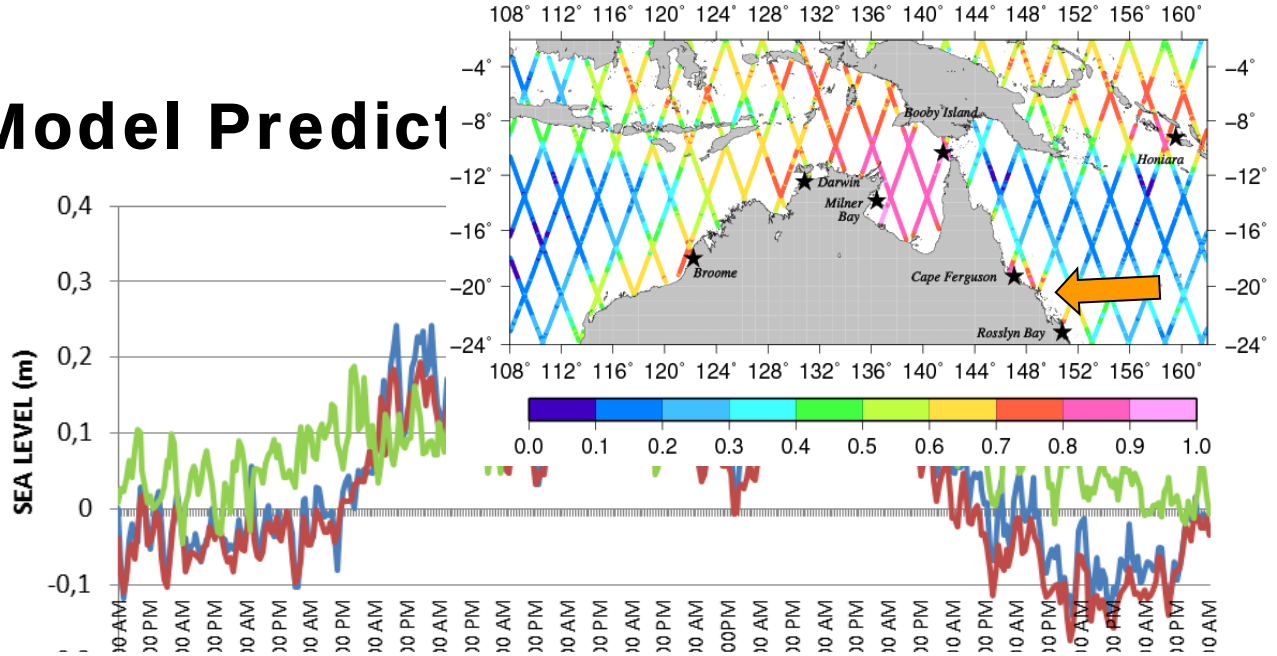
Regression Model

$$\eta_{Jason}(t) = \beta_1 ssh_1(t) + \beta_2 ssh_2(t) + \beta_3 ssh_3(t) \cdots + \varepsilon$$

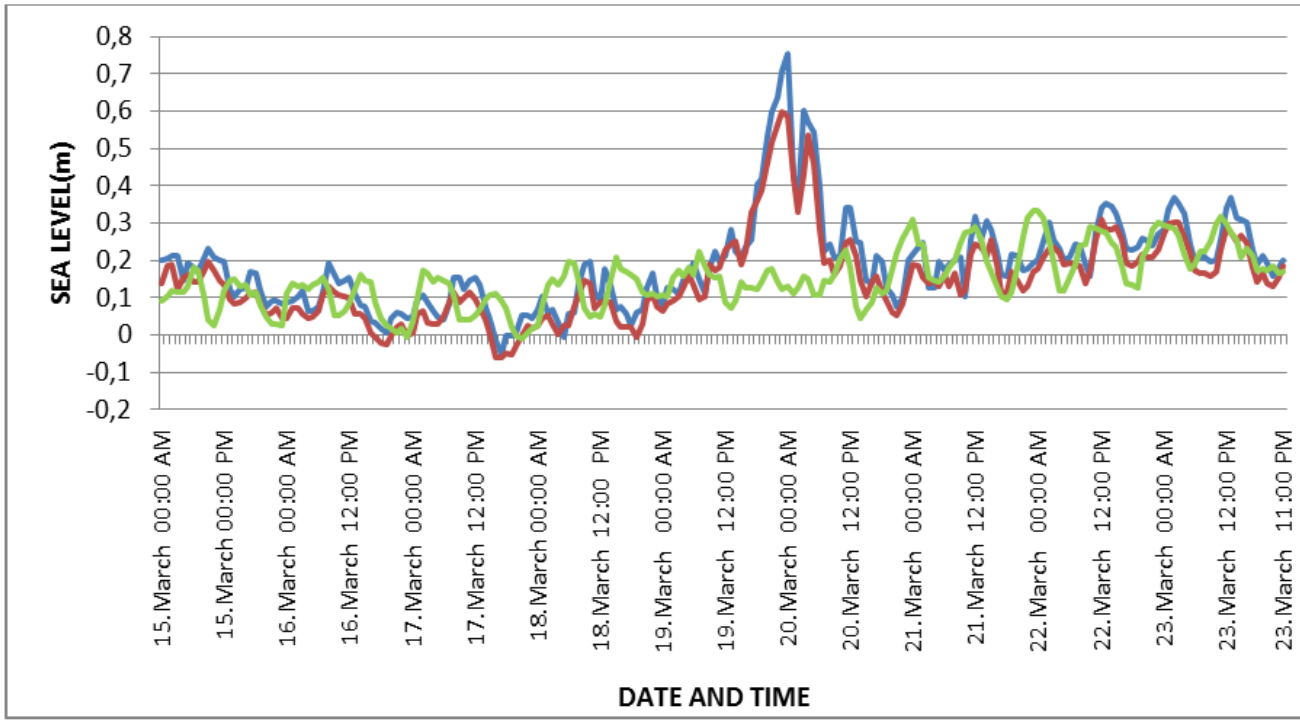


Model Predict

Cyclone Helen (January, 04, 2008)



Cyclone Larry (March 19th, 2006)



Blue=Tide gauge obs

Green=Tide gauge alone

Red=Altimetery + TG

Conclusions

- Satellite altimetry has proven very valuable t
  - North Sea: Two Sat detection capturing >90% of high water scen
  - NE Australia: One sat detection captures most cyclone related sur advance.
  - Some of these left uncaptured from tide gauges alone.
  - Analysis in Eastern Australia is still ongoing (ph.d. Project).

- Future:
- Jason-2 is very important for surge forecast (however current in saf
- Cryosat-2 has non systematic ground track pattern but applicable.
- AltiKa has potential. Potential problem with rain is currently under in seems far less serious as expected (smaller footprint).
- Sentinel-3 (2014/2015) + Jason-3 will offer systematic ground track additional information in the future.