In this study, the performance of recently regional and global tidal models in tidal constituent estimation and tidal height prediction over the Great Barrier Reef, Australia is assessed. Nine models, including TPX08, EOT11a, HAMTIDE, FES2012, OSUNA, OSU12, GOT 4.10 and DTU10, were considered.

To evaluate the accuracy of the models in tidal constituent estimation, eight major constituents (i.e., $K_1$, $O_1$, $P_1$, $Q_1$, $M_2$, $S_2$, $N_2$ and $K_2$) were extracted based on analyzing sea level observations in 926 altimetry along-track locations and tide gauge stations using the response method and harmonic analysis, respectively. The outcomes involved in this model’s RSS calculation.

In addition, to assess the performance of each model, the root sum square (RSS) is calculated using the RMS of the SLA residuals (SLAR) was computed as:

$$\text{RSS} = \sqrt{\sum_{i=1}^{L} \left( \text{SLA}_{\text{predicted}} - \text{SLA}_{\text{observed}} \right)^2}$$

(4)

where $T$ is the number of constituents.

## 2. GREAT BARRIER REEF

- The largest reef system in the world with more than 2500 coral reefs [1].
- The strip of coral reefs is ~2600 km long and ~200 km wide with an average depth ~35 m in its inshore waters
- Nine tidal models are considered:
  - TPX08
  - FES2012
  - OSUNA
  - OSU12
  - GOT4.10
  - DTU10
  - EOT11a
  - HAMTIDE
  - DTU10 (7.5')

## 3. MODELS AND DATA

### 3.1. Models

- EOT11a (7.5')
- DTU10 (7.5')
- HAMTIDE (7.5')
- OSU12 (15')
- OSUNA (2.5')
- FES2012
- FES2014
- GOT4.10

### 3.2. Data

- Shelf Zone: 40 m < Depth < 400 m
- Coastal Zone: 0 m < Depth < 40 m
- Ocean Zone: 400 m < Depth

## 4. METHOD

For a given constituent $i$, the RMS of misfit, between model and observed tidal constants, is calculated as

$$\text{rms}_i = \left( \frac{1}{N} \sum_{n=1}^{N} (\text{m}_{ni} - \text{o}_{ni})^2 \right)^{1/2}$$

(3)

where $L$ is the number of positions in a zone, superscripts $m$ and $o$ stand for the model output and observed tidal constants, respectively, and $H_i$ is the complex expression of tide amplitude and phase at position which is computed as:

$$H_i = \text{A}_i \text{cos} (2\pi f_i t + \text{G}_i)$$

(2)

where $A_i$ is the tidal amplitude, $f_i$ the frequency of the tidal constituent, $t$ the Greenwich phase of the constituent for the $i$-th position. Considering the real part of Eq. (2) gives:

$$\text{rms}_i = \left( \frac{1}{N} \sum_{n=1}^{N} (\text{m}_{ni} - \text{o}_{ni})^2 \right)^{1/2}$$

(3)

In addition, to assess the performance of each model, the root sum square (RSS) is calculated using the RMS of the selected tidal constituents as

$$\text{RSS} = \sqrt{\sum_{i=1}^{8} \text{rms}_i^2}$$

(4)

## 5. ABILITY TO ESTIMATE TIDAL CONSTANTS

- The two main semi-diurnal constituents, $M_2$ and $S_2$, are the most inaccurate components for all the models.
- The mean RSS (in cm) of all 8 major tidal constants for the tidal models over different zones of the study area. This is compatible with all previous studies that have shown tidal regime of this region to be of mainly semi-diurnal pattern.
- Overall, except for the twin model EOT11a and EOT11ag, HAMTIDE, OSU12 and GOT4.10 models show a similar accuracy ranging from ~24 to ~30 cm of RMS over coastal.
- At the coastal, shelf and deep ocean zone FES models, DTU10, TPX08 and GOT 4.10 feature the most efficient models in terms of prediction ability with the mean RMSs of ~9 – ~14 cm (coastal zone), ~7 to ~11 cm (shelf zone) and ~7 cm (deep ocean zone). Models EOT11a, EOT11ag and OSUNA form the second group with mean RMSs up to ~21 cm (coastal zone), ~18 cm (shelf zone) and ~15 cm (deep ocean zone).

## 6. ABILITY TO PREDICT TIDAL HEIGHT

- The SLAs of the tide gauges and Sentinel-3A along-track positions are detided using tidal heights (TH) that are estimated by different models and consequently SLA residuals (SLAR) are calculated based on Eq. (5).

$$\text{SLAR} = \text{SLA} - \text{TH}$$

(5)

## 7. DISCUSSION

### 7.1. Discussion

- As expected, regional model OSUNA, which was efficient in estimation of the four major tidal constituents in the coastal and shelf zones (Figs. 3b, c), is marked as the most inaccurate model in terms of tidal height prediction ability over shelf and deep ocean zones. The less available tidal components in this regional model can be the reason that affects its tidal prediction performance.
- The geographic range, between latitudes from -19° to -23° and longitudes from 148° to 153°, due to highly variant bathymetry and existence of the coral reefs features the area where the constituents show intense variation in comparison to other zones of the GBR.
- Models TPX08, FES2012, FES2014, GOT 4.10 and DTU10 have RMS of ~9 – ~15 cm, ~6 – ~12 cm and ~7 cm showing better performance over coastal, shelf and deep ocean zone respectively.
- A combination of intense variations of bottom topography in the challenging zone and existence of coral reefs and small islands contribute to the model’s accuracy and performance.
- The influence of GRACE data in tidal analysis over this region was revealed to be insignificant showed by the comparison between prediction ability of EOT11a and EOT11ag.
- Prediction performance of FES2012 is 55% better than it’s successor over the challenging zone.

### 8. REFERENCES