Short-term morphological changes of multiple intertidal bars on macrotidal beaches: from seasonal to storm-scales

M. Biausque, E. Grottoli, D.W.T. Jackson and J.A.G. Cooper
Contact: m.biausque@ulster.ac.uk

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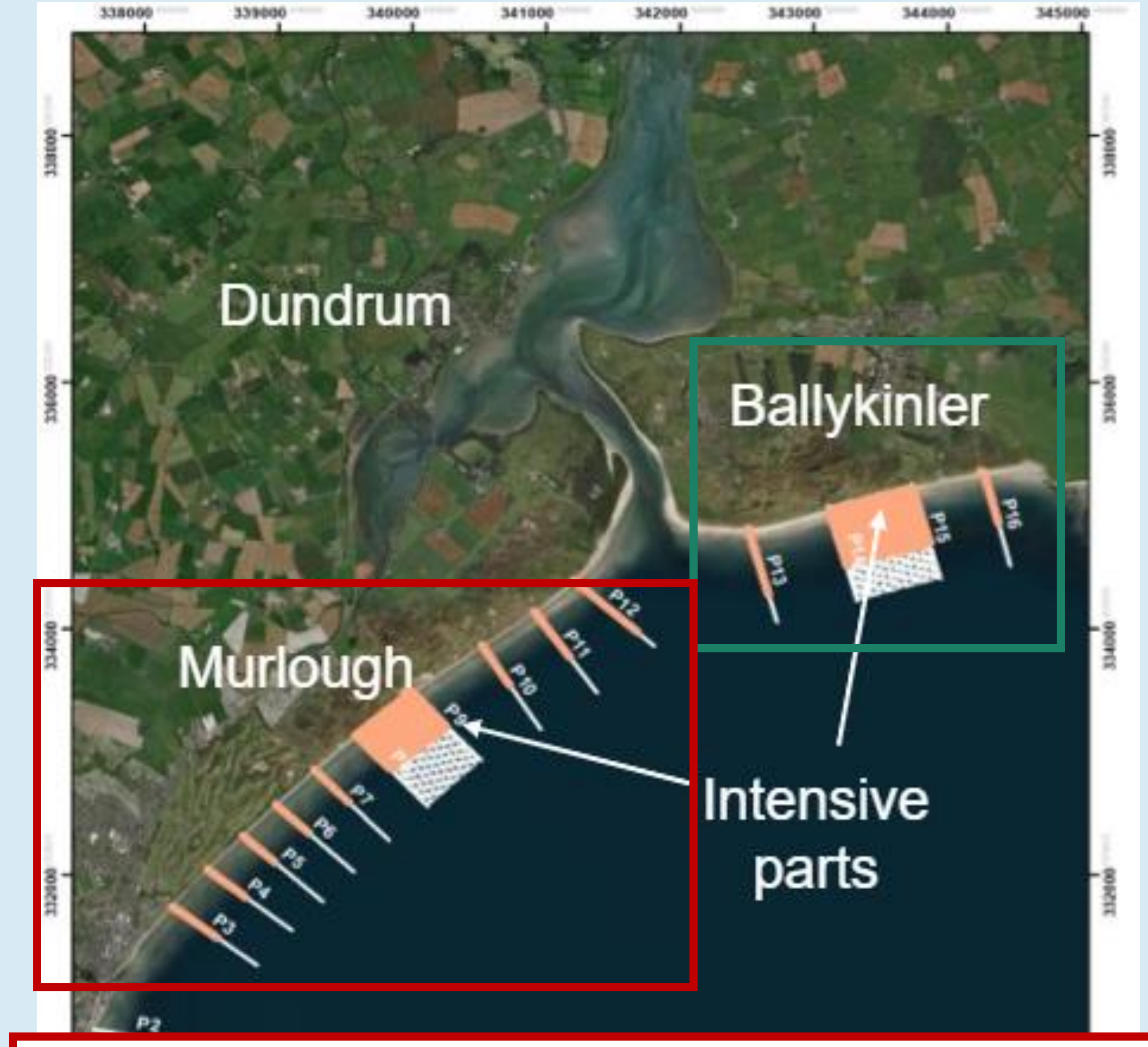
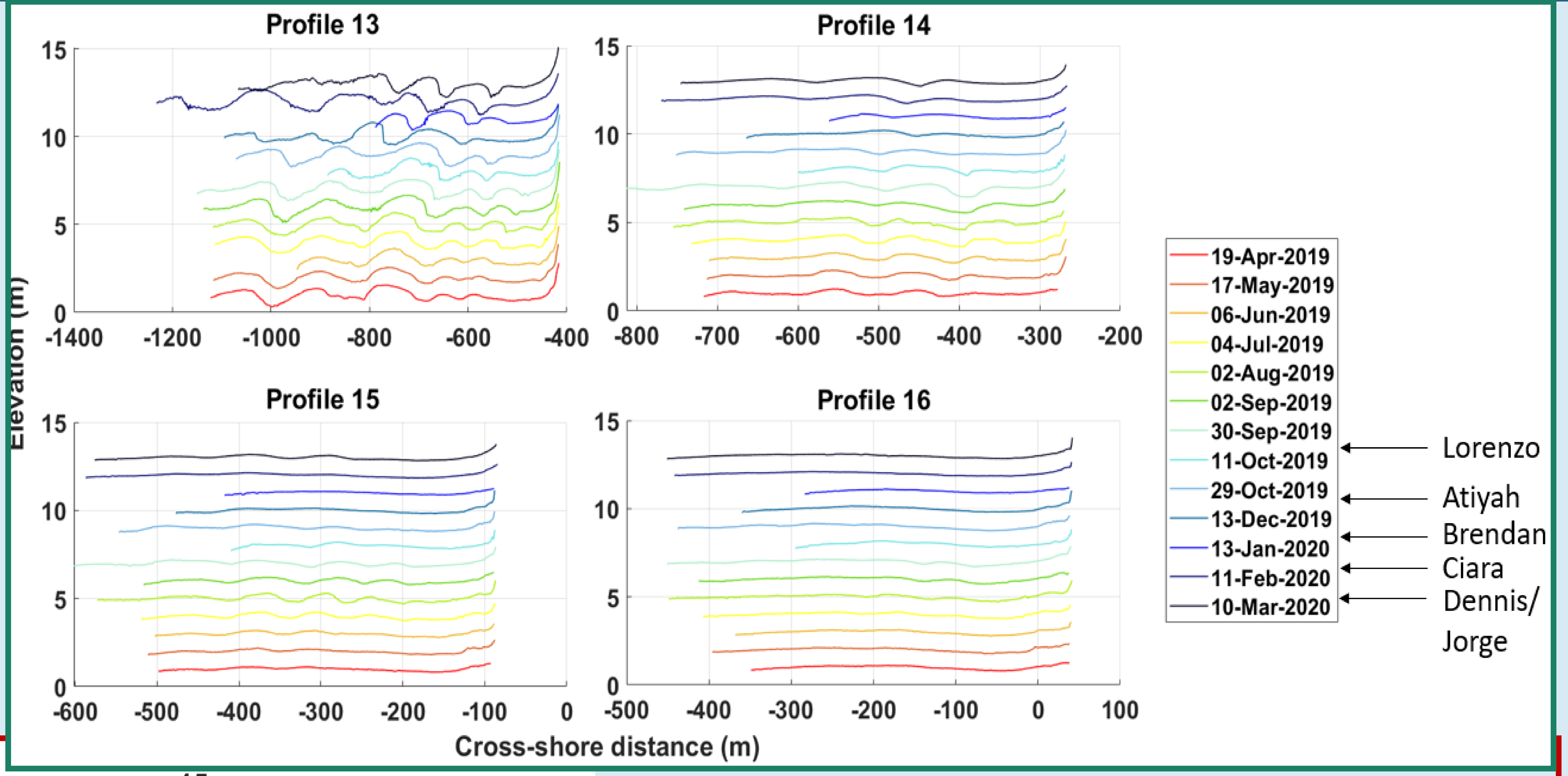
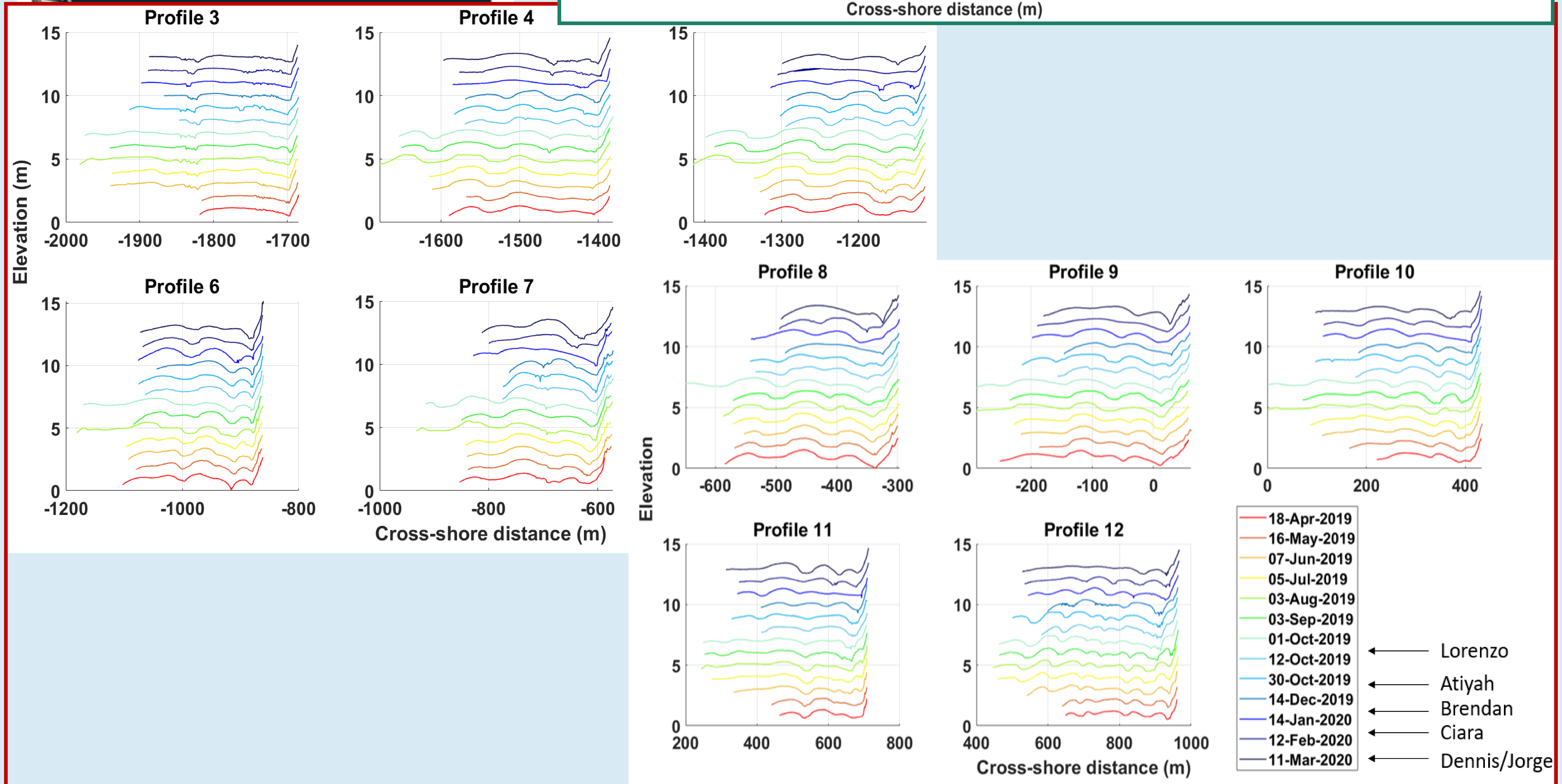
Vienna | Austria | 3–8 May 2020







- Seasonal morphological changes of MITB features:
  - ❖ **Summer:**
    - ➢ **Increase** in pre-existing bar **amplitudes** or formation of ridges
    - ➢ **Onshore bar migrations** mostly observed, **but high alongshore variability** in MITB response to the summer season
  - ❖ **Winter:**
    - ➢ **Erosion and onshore migrations** of bar crests, flattened profiles, but high **alongshore variability**
    - ➢ Mostly **driven by energetic events** and pre-seasonal morphology

- **Event scale:**
  - ❖ **Storm conditions**: energy, diffraction/refraction, duration
  - ❖ **Pre-storm profile morphology**
    ➔ Strong alongshore variability: crests erosion, bars migration, recovery
  - ❖ **Bars shape and number**

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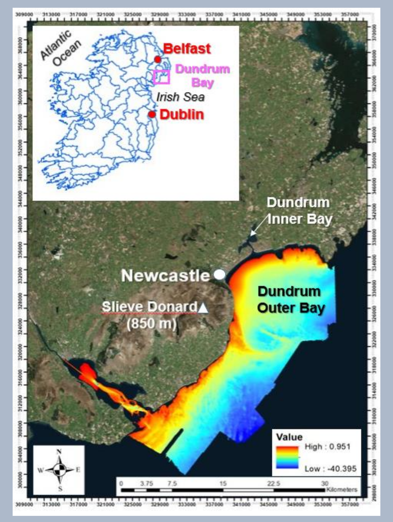
Introduction

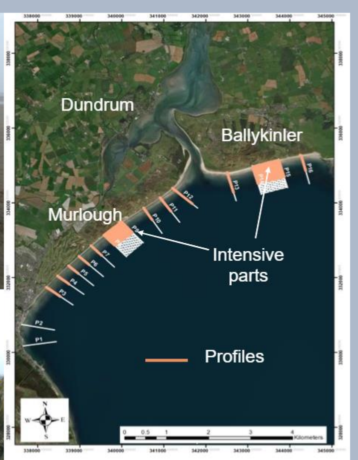
- Investigate short-term morphological changes of coastal environment is the first step toward a better understanding of shoreline retreat and vulnerability in a context of climate change
- Develop durable MPA management plans
- Study little-known environments called Multiple Intertidal Bar (MITB) systems (or 'Ridges and Runnels')
- Opposite reports about MITB seasonal behaviours

Field Sites



- Dundrum Bay, Co. Down, located on the east coast of Northern Ireland
- Two sites: Murlough beach (National Trust) and Ballykinler beach (MOD)
- Semidiurnal tides, macrotidal environment (5.5 m)
- Low to moderate wave energy (restricted fetch of Irish Sea)
- Medium to coarse sand
- Multiple Intertidal Bars (MITB) system (up to 6 ridges)

Methods



- Monthly intertidal topographic surveys now underway
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- 4 profiles at Ballykinler beach
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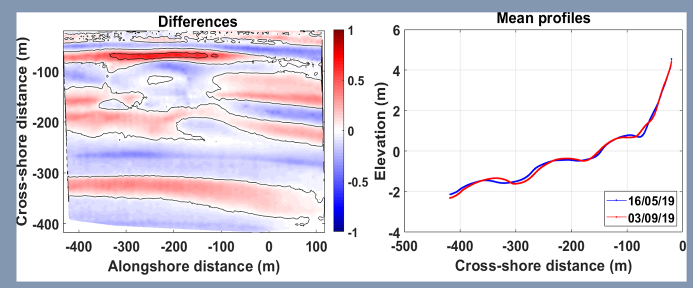
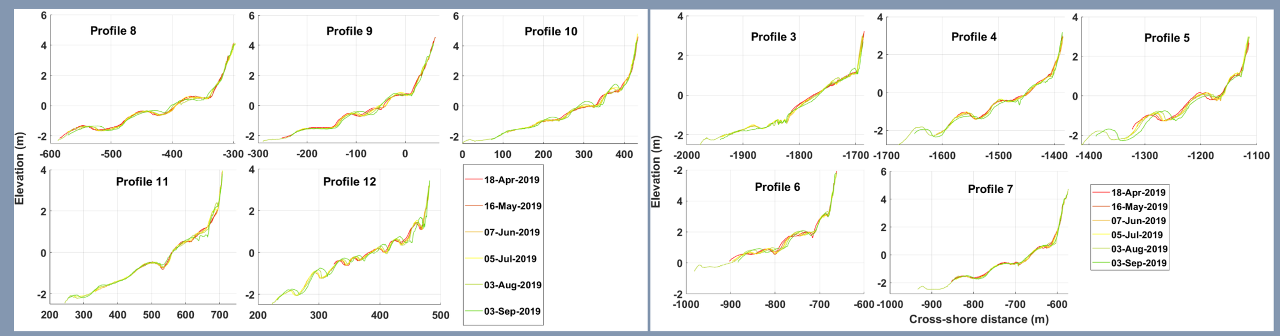
Results & Discussions

Summer variations (May to September) at Murlough beach

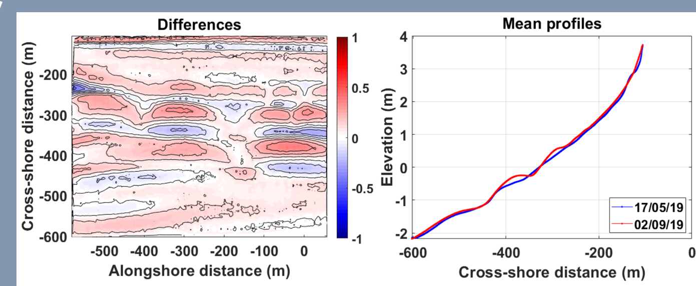


- Differences between 16/05/19 and 03/09/19
- Cross-shore erosion/accretion sequencing resulting from cross-shore bar migration

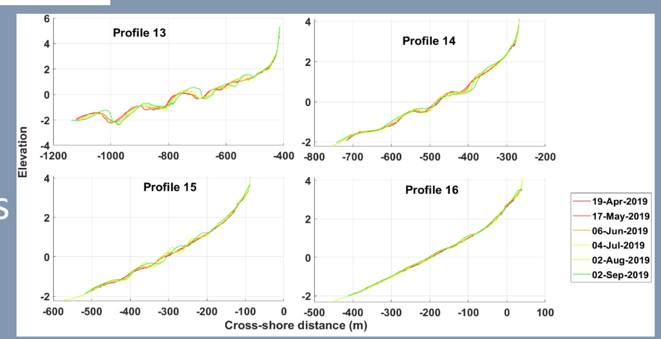


- Increase of MITB features toward the inlet (P12)
- Onshore bar migration at profiles 4,5,6,8,9 and 12
- Decrease or Increase of bars amplitude depending on profiles
- No significant changes at profiles 3,7 and 11
- High alongshore variability of the beach response to the summer season

Summer variations at Ballykinler beach

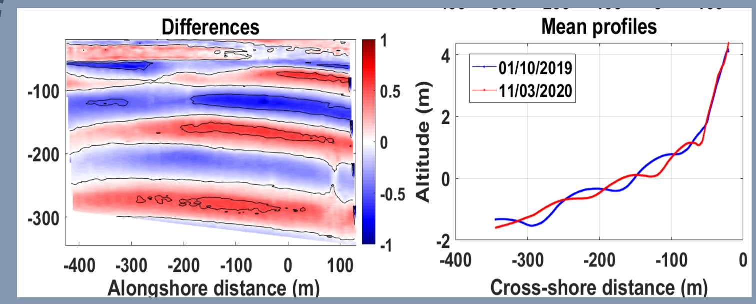


- Differences between 17/05/19 and 02/09/19
- Patches of accretion and erosion: formation of ridges according to mean profiles

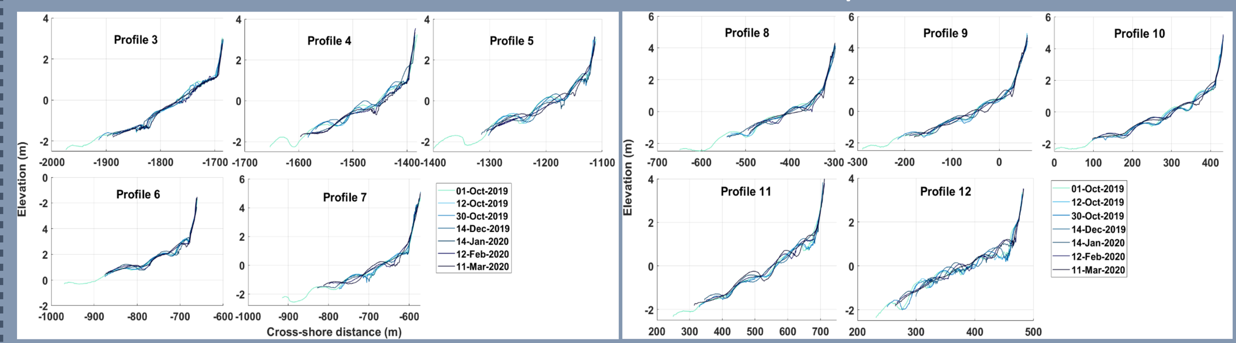


- Increase of MITB features toward the inlet (P13)
- No MITB at profile 16
- Formation/Increase of bars amplitude
- Onshore bar migrations

Winter variations (October to March) at Murlough beach

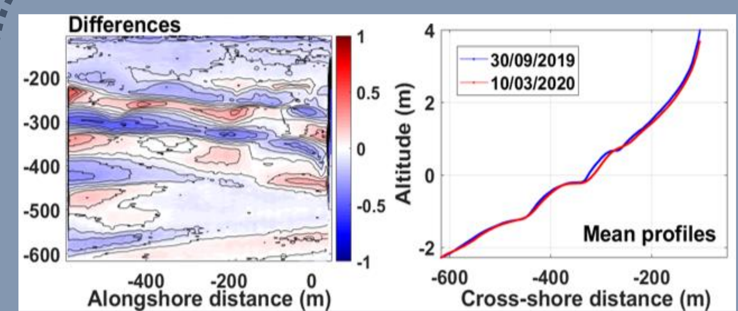


- Differences between 01/10/19 and 11/03/20
- Cross-shore erosion/ accretion sequencing: cross-shore migration /crests erosion

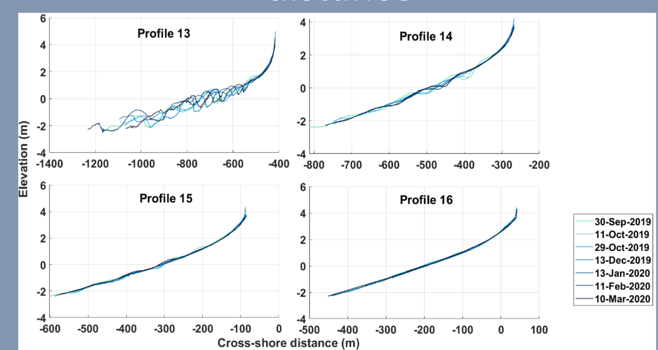


- Onshore bar migrations
- Erosion of bar crests
- Flattening of profiles
- High alongshore variability
- Highly driven by energetic events as storms

Winter variations at Ballykinler beach

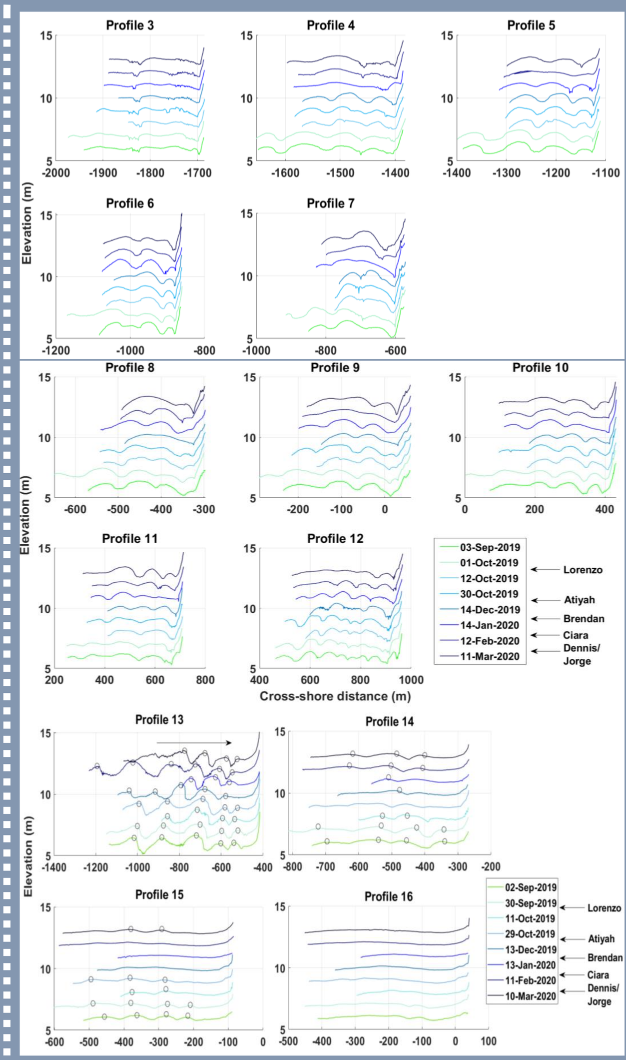


- Differences between 30/09/19 and 10/03/20
- Cross-shore erosion/accretion: -200 to -400 m cross-shore distance



- Onshore migrations, crests erosion, profiles flattened
- Alongshore variability depending on the pre-seasonal morphology

Storm activities and impact on MITB morphologies



- Lorenzo: no significant change, except P7
- Atiyah: flattening P8, 14 and 15; erosion most seaward bar P9
- Brendan: flattening P4 and 7; recovery P8 and 9; erosion most landward bar P10, 11 and 12; onshore migration of bars P13
- Ciara: : flattening P5 and 9; recovery P4, 7 and 14; recovery most landward bar P11
- Dennis/ Jorge: flattening P5 and 12; recovery P5 and 7; recovery most landward bar P9, 10 and 15; erosion of the most seaward bar P13

	Lorenzo	Atiyah	Brendan	Ciara	Dennis	Jorge
Mean H_s (m)	0,49	3,14	3,27	3,24	3,07	2,94
Max H_s (m)	0,64	2,72	4,53	4,04	3,87	3,75
Mean T_p (s)	9,7	6,0	7,8	8,1	7,9	6,8
Mean Dir (°)	187	188	182	189	185	198
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Duration (Hrs)		15	18	30	48	18
Storm Power Index (Ps)		148	369	489	719	253

- Storm definition: Hs > 2,35 m for more than 15 hours
- Same direction → Potential diffraction/refraction in the bay due to nearshore bathymetry?
- Impact of storm driven by the pre-storm morphology → recovery of profiles may be initiated at the next storm
- Storm- generated erosion: mostly concern the upper system (landward bar) →role of the tide?

Conclusions

- Seasonal morphological changes of MITB features:
  - Summer:
    - Increase in pre-existing bar amplitudes or formation of ridges
    - Onshore bar migrations mostly observed, <u>but</u> high alongshore variability in MITB response to the summer season
  - Winter:
    - Erosion and onshore migrations of bar crests, flattened profiles, <u>but</u> high alongshore variability
    - Mostly driven by energetic events and pre-seasonal morphology
- Event scale:
  - Storm conditions: energy, diffraction/refraction, duration
  - Pre-storm profile morphology → Strong alongshore variability: crests erosion, bars migration, recovery
  - Bars shape and number

Perspectives

- Quantify crest migration rates and shape/amplitude changes of bars
- Look at the impact of tidal moment on the beach response to events
- Pursue field measurements
- Modeling of the wave energy dissipation to investigate the alongshore variability of the system

Acknowledgements

This work is part of the INTERREG MarPAMM project. The authors would also like to thank the MOD and the National Trust for their help and a full access to our field sites located on their lands, and the Ifremer (France) for the wave dataset.

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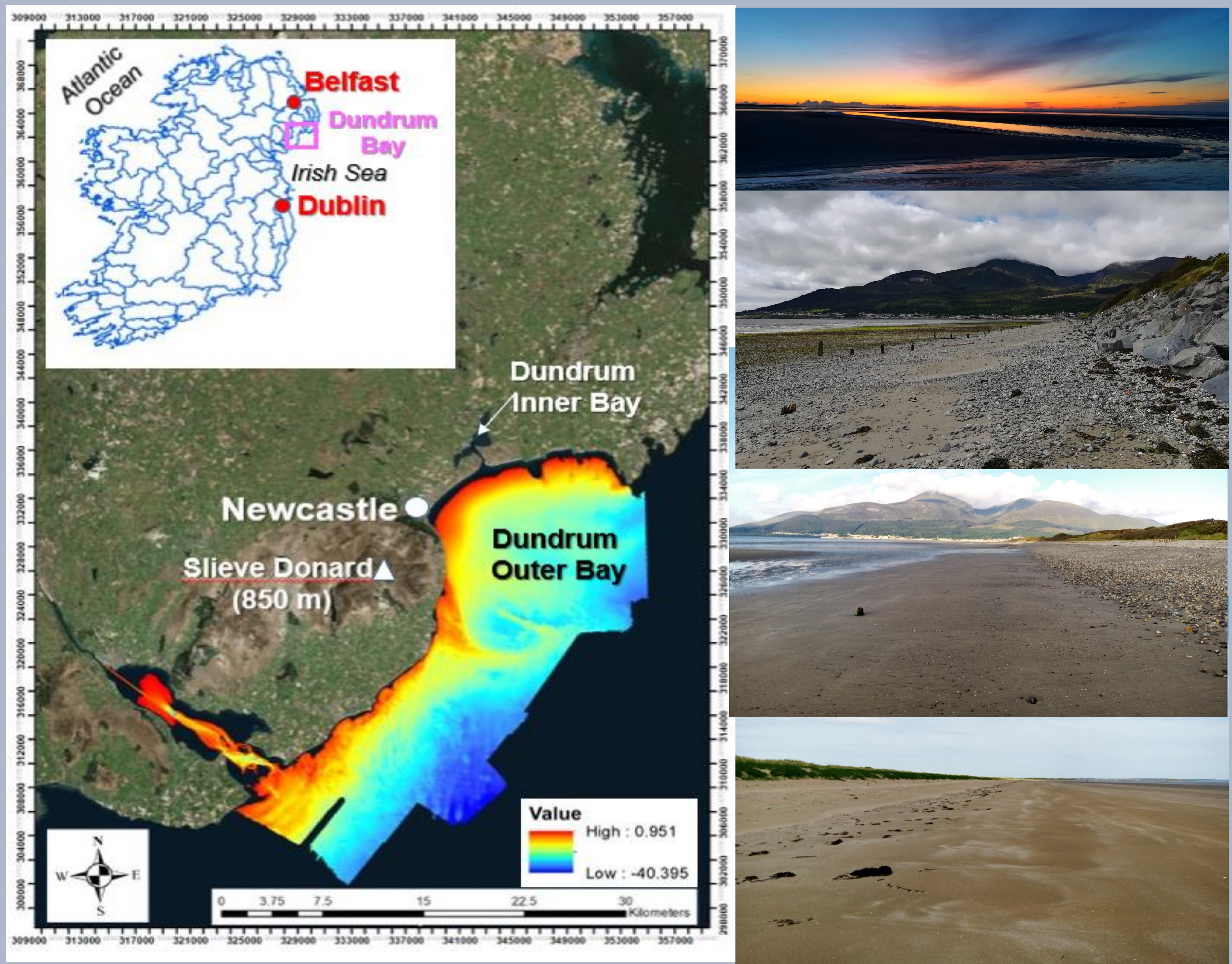

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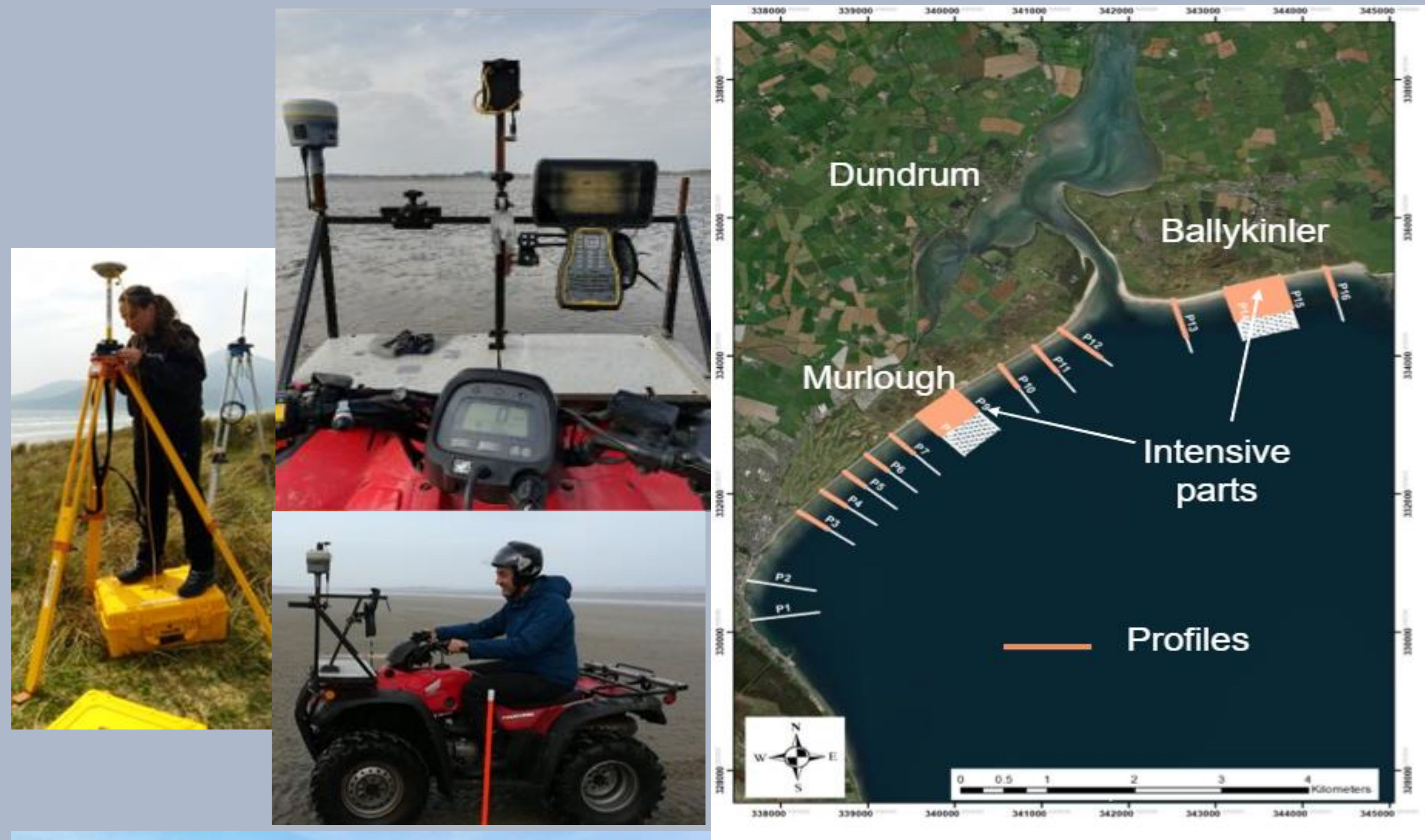

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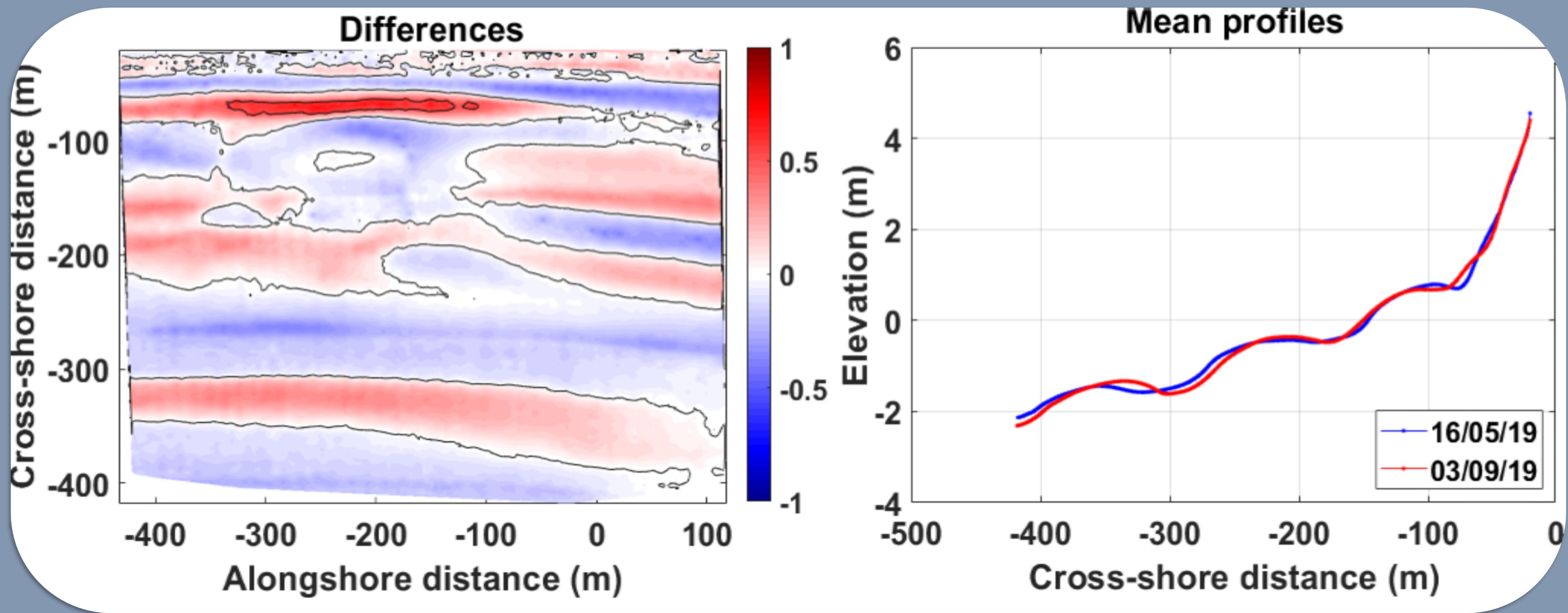
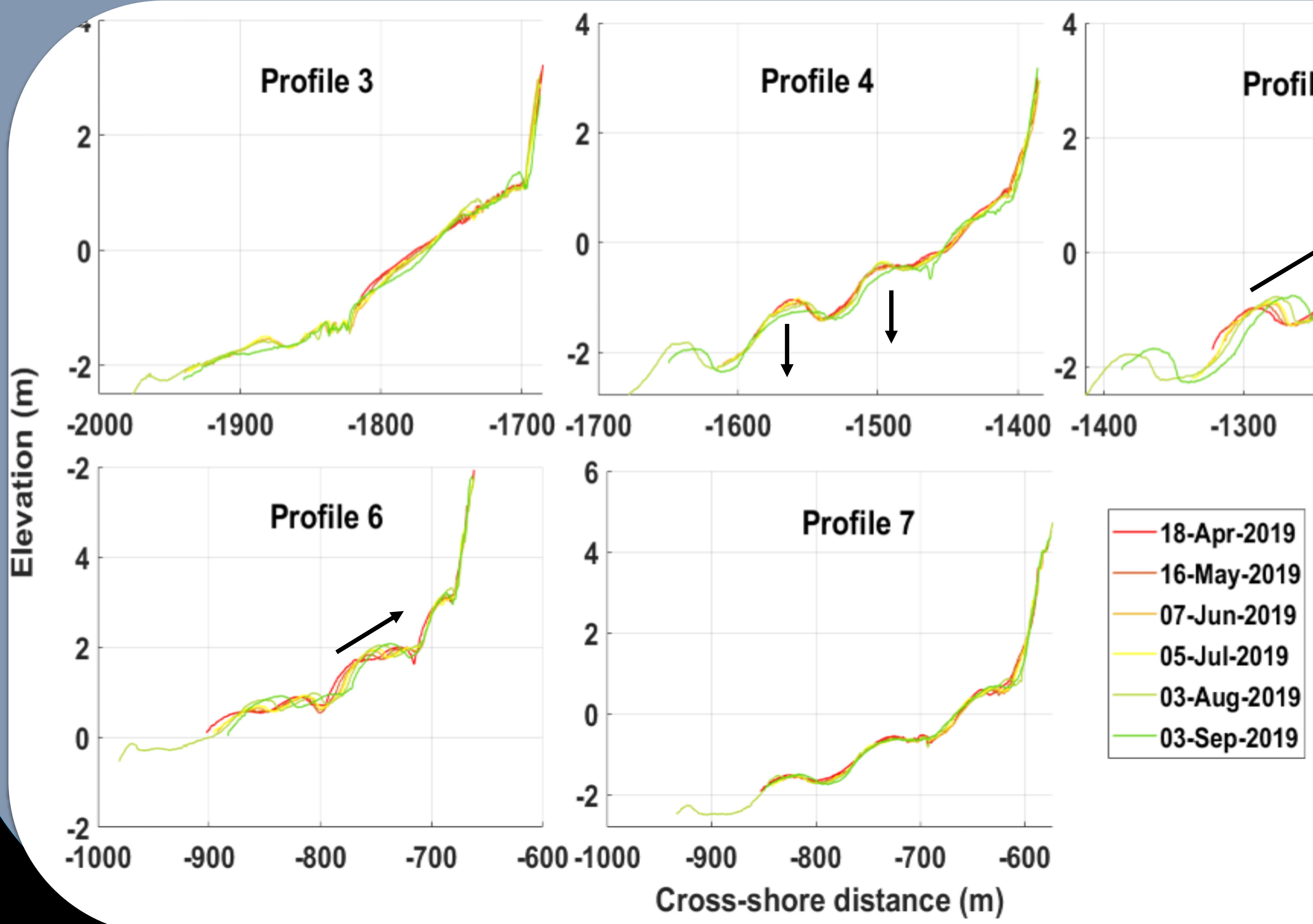


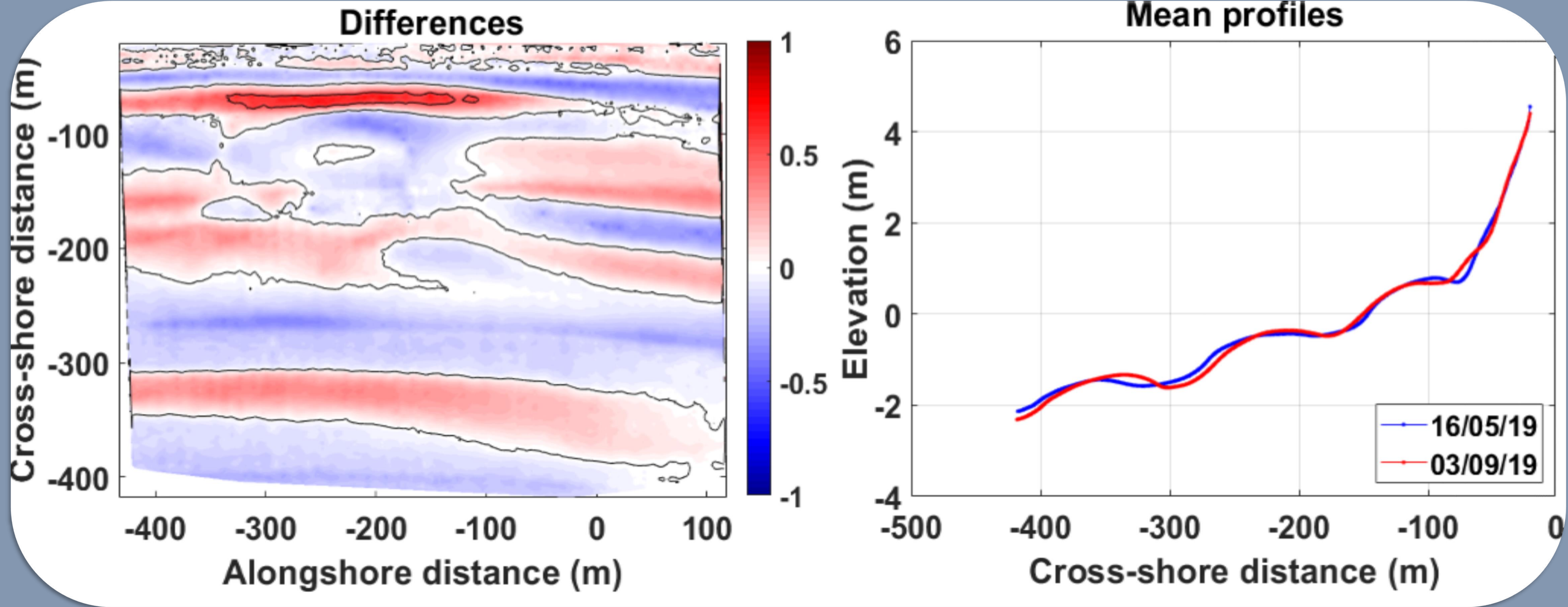
- ➢ Summer period included between May to September 2019
- ➢ Intensive area of DGPS surveys along 500m alongshore : one profile every 15m
- ➢ Morphological differences measures between May the 16th and September the 3rd
- ➢ Cross-shore erosion/accretion sequencing resulting from cross-shore bar migration



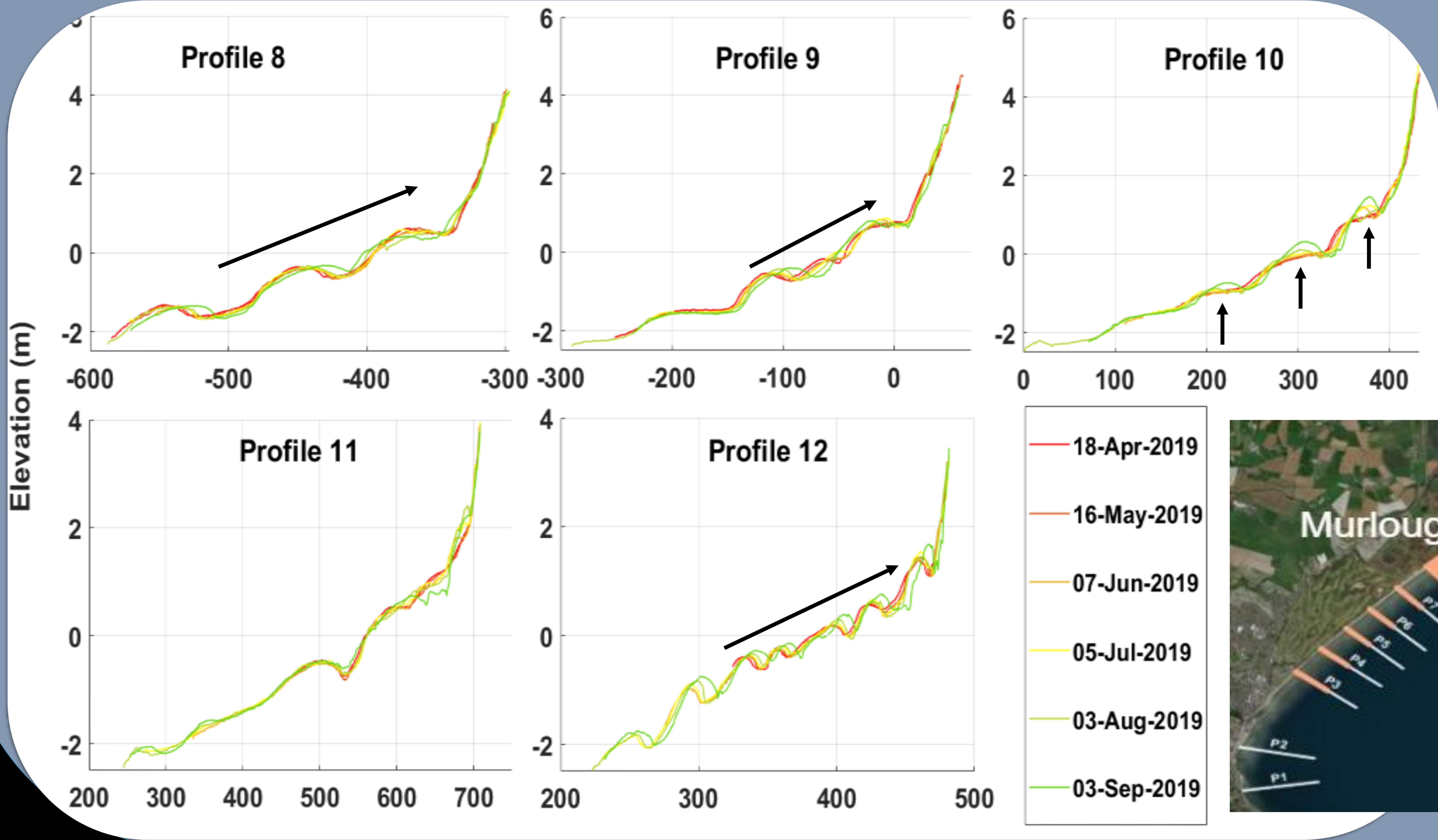
- ➢ Profile 3: complex profile due to the presence of numerous pebbles along the profile
- ➢ Onshore migration at profiles 4, 5 and 6
- ➢ Flattening of bar crests at profile 4
- ➢ No significant changes of the profile 7

Results & Discussions

- Summer variations (May to September) at Murlough beach



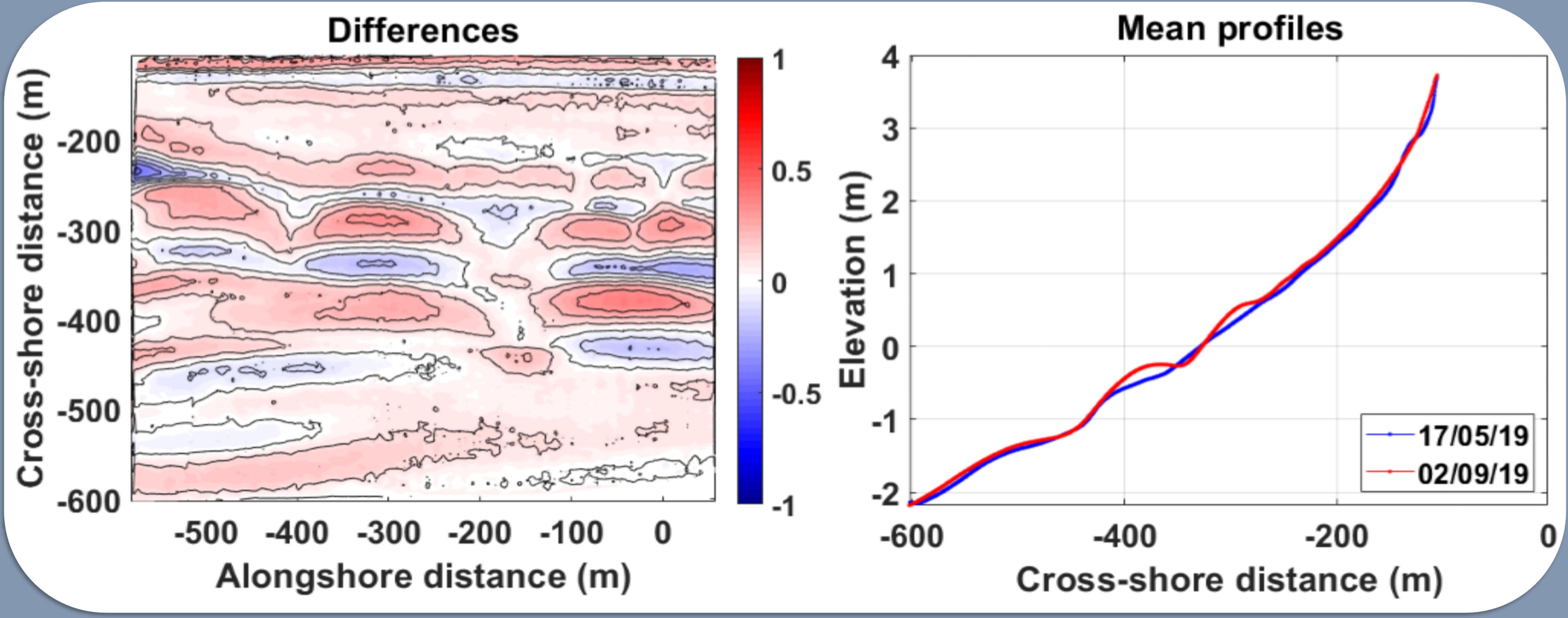
- Increase of MITB feature toward the inlet (profile 12)
- Landward migration of ridges at profiles 8, 9 and 12
- Increase of the bar amplitude at profile 10
- No significant changes at profile 11, except an erosion of the most landward ridge



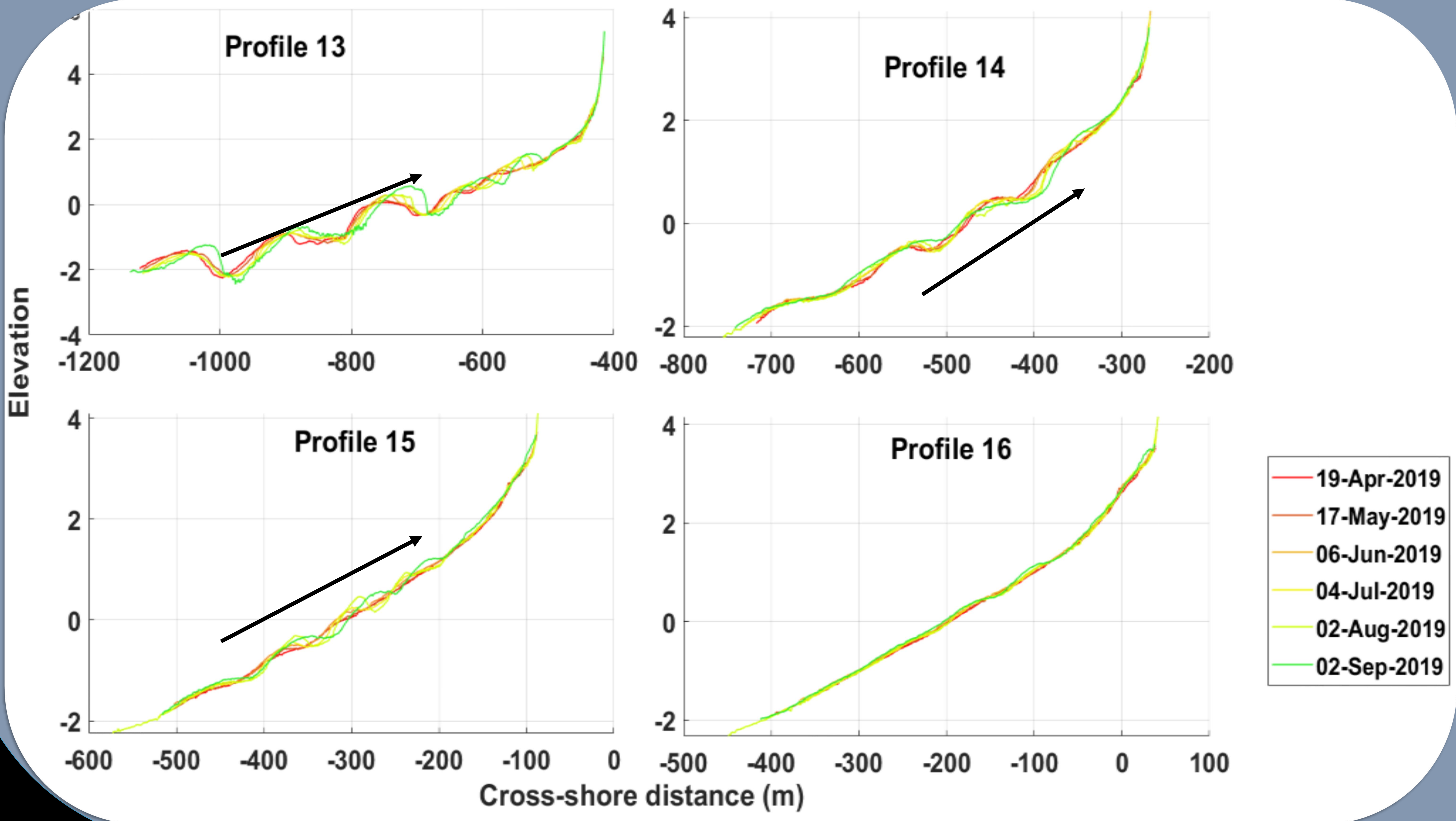
- **Onshore migration of bars**
- **Decrease or Increase of bars amplitude depending on profiles**
- **High alongshore variability of the beach response to the summer season**

Results & Discussions

- Summer variations (May to September) at Ballykinler beach



- Summer period included between May to September 2019
- Intensive area of DGPS surveys along 700m alongshore : one profile every 15m
- Morphological differences measures between May the 17th and September the 2rd
- Patches of accretion and erosion, due to the formation of ridges according to mean profiles plot

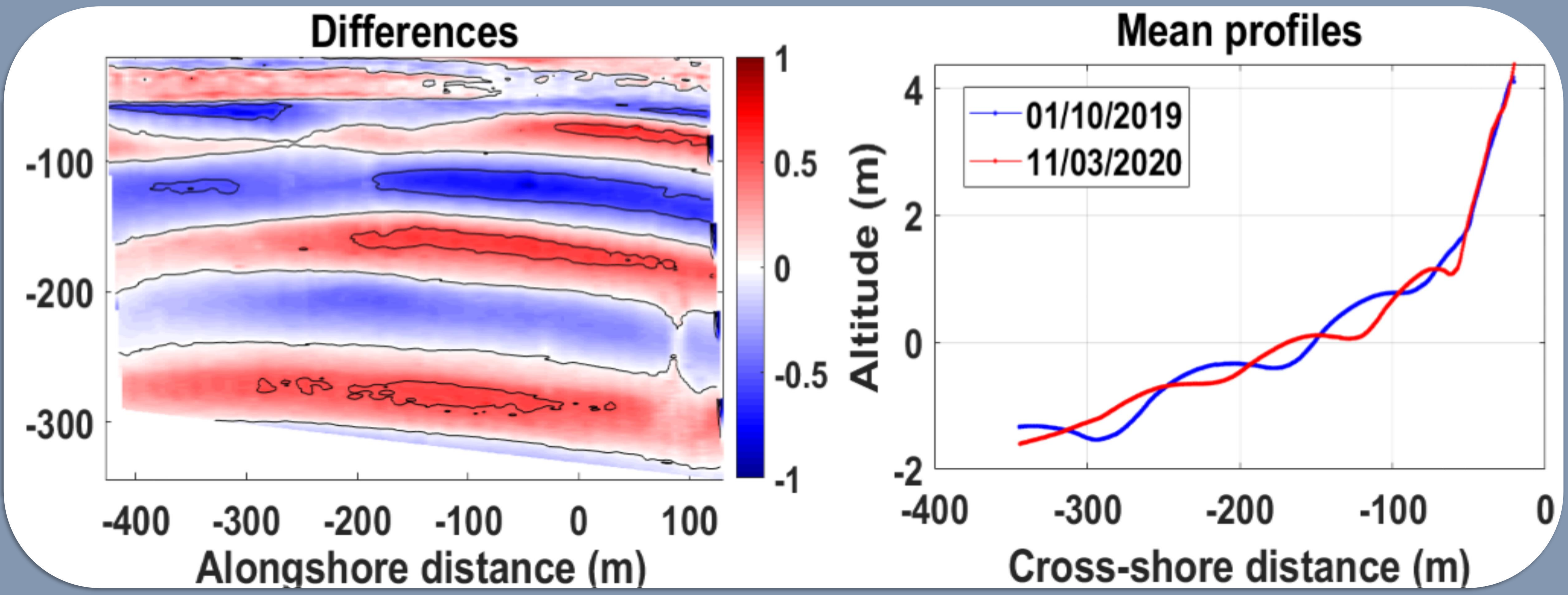


- Onshore migration of ridges and increase of their amplitude, profiles 13,14 and 15
- Formation of ridges at profile 16
- Increase of MITB feature toward the inlet (profile 13)

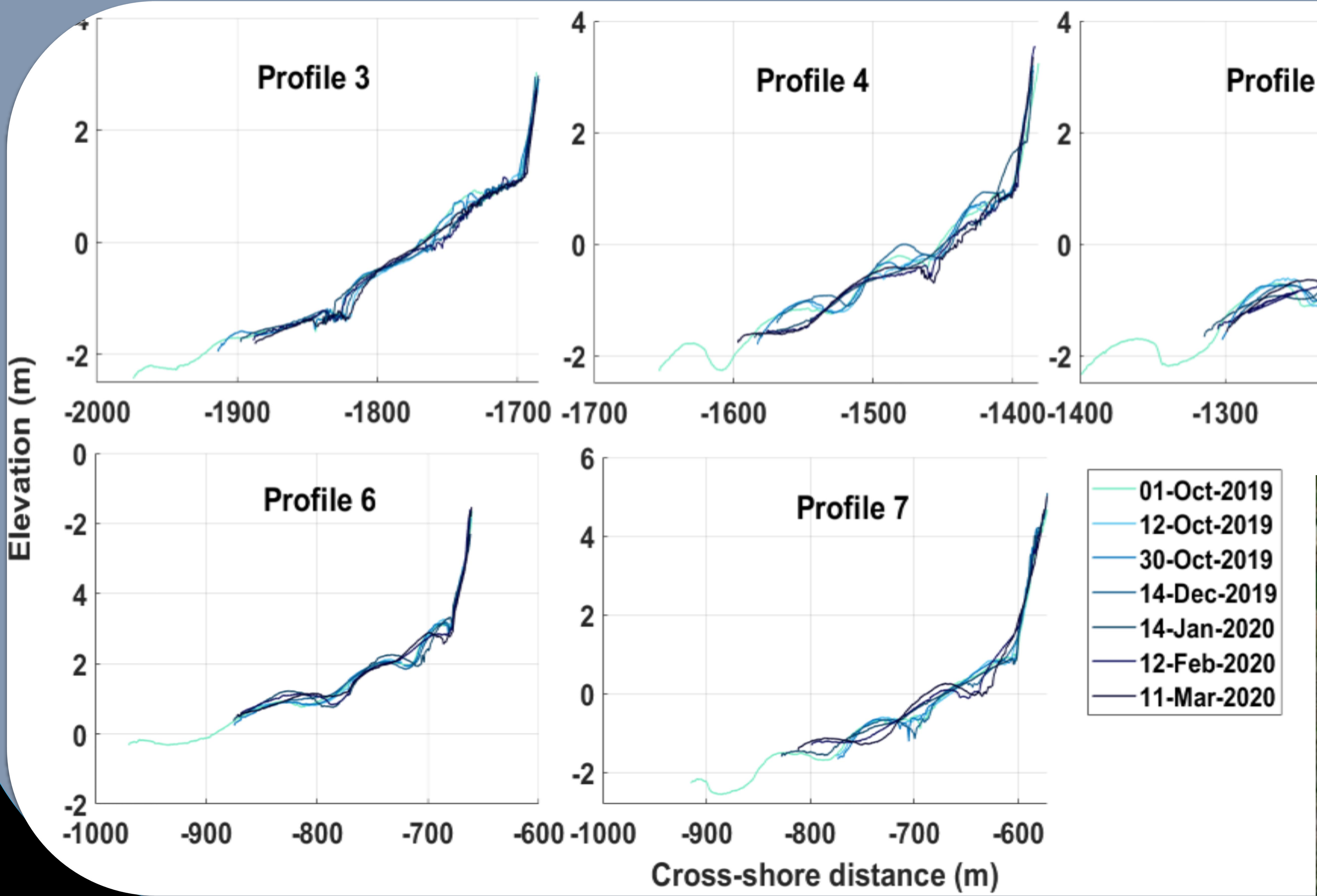
- **Formation/Increase of bars amplitude**
- **Onshore bar migrations**

Results & Discussions

- Winter variations (October to March) at Murlough beach



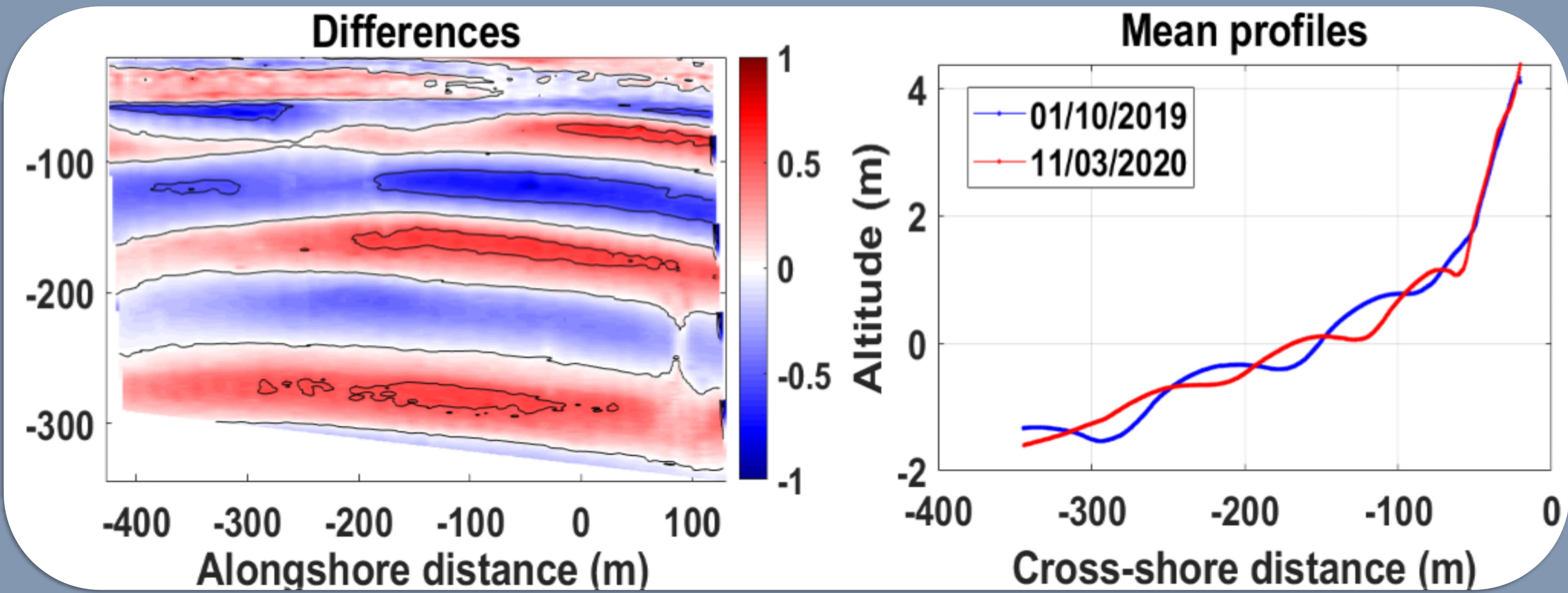
- ➢ Winter period included between October 2019 to March 2020
- ➢ Morphological differences measures between October the 1st and March the 11th
- ➢ Cross-shore erosion/accretion sequencing resulting from cross-shore bar migration and erosion of crests



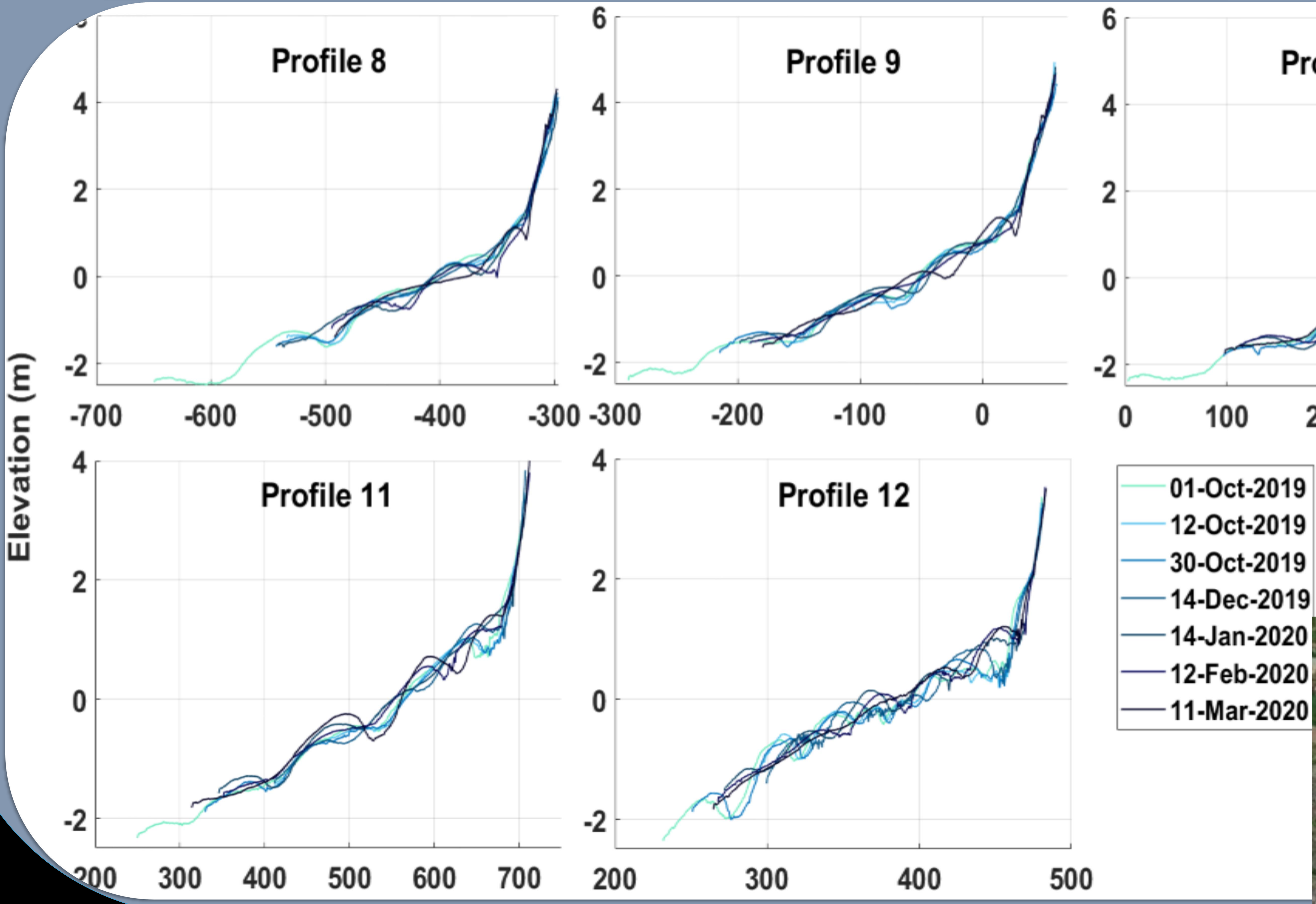
- ➢ Onshore bar migrations from October to December, profiles 4,5,6 and 7
- ➢ Flattening of bar crests in January: erosion of ridges at profiles 4,5 and 7
- ➢ Ridge recovery at profiles 5 and 7 in February
- ➢ Onshore migration in March, profile 5

Results & Discussions

- Winter variations (October to March) at Murlough beach



- P8 and 10: bars stability until December, erosion of the most landward bar + onshore migration of the other bars in January. Flattening of the entire P8 in March
- P9: onshore bars migration until January, bar crests erosion in February followed by a recovery of bars in March
- P11: 3 to 4 bars in December, increase of bar amplitudes the rest of the season, erosion of the most seaward bar in February
- P12: onshore migration until January, progressive erosion of the 3 seaward bars toward a flattened profile in March



- **Onshore bar migrations**
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- **High alongshore variability**
- **Highly driven by energetic events as storms**

Results & Discussions

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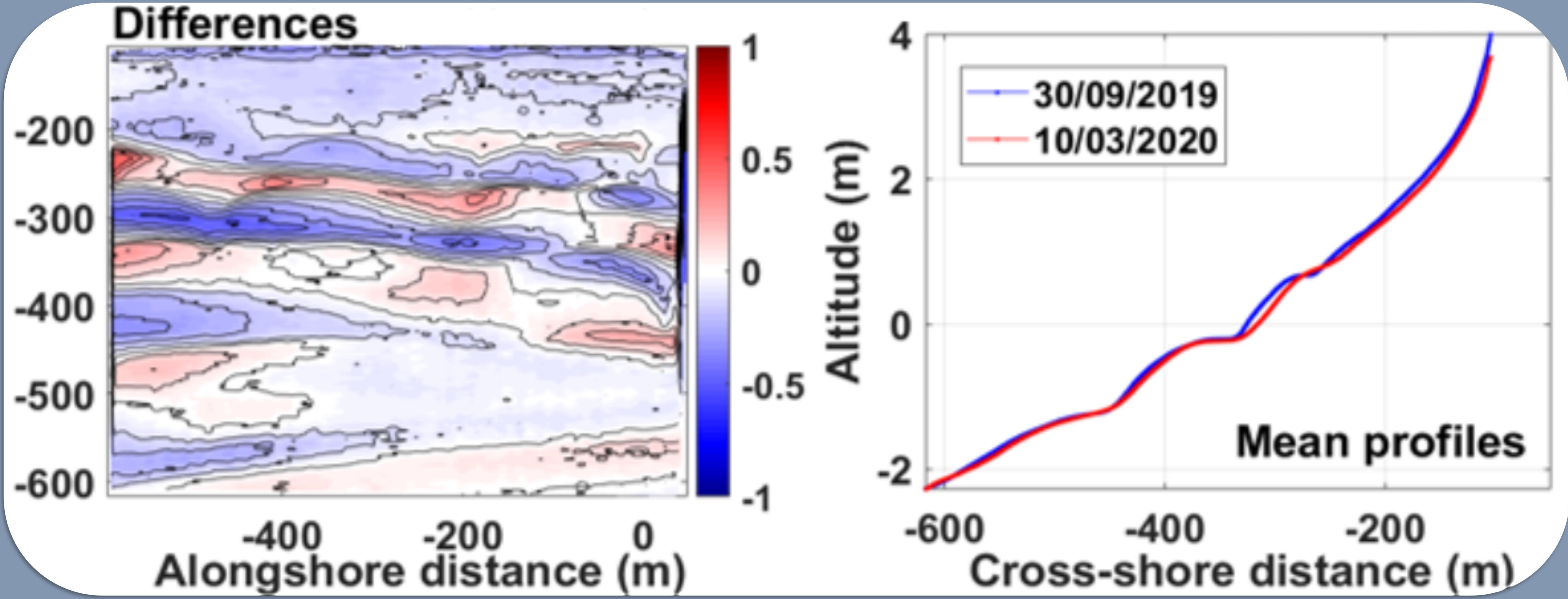
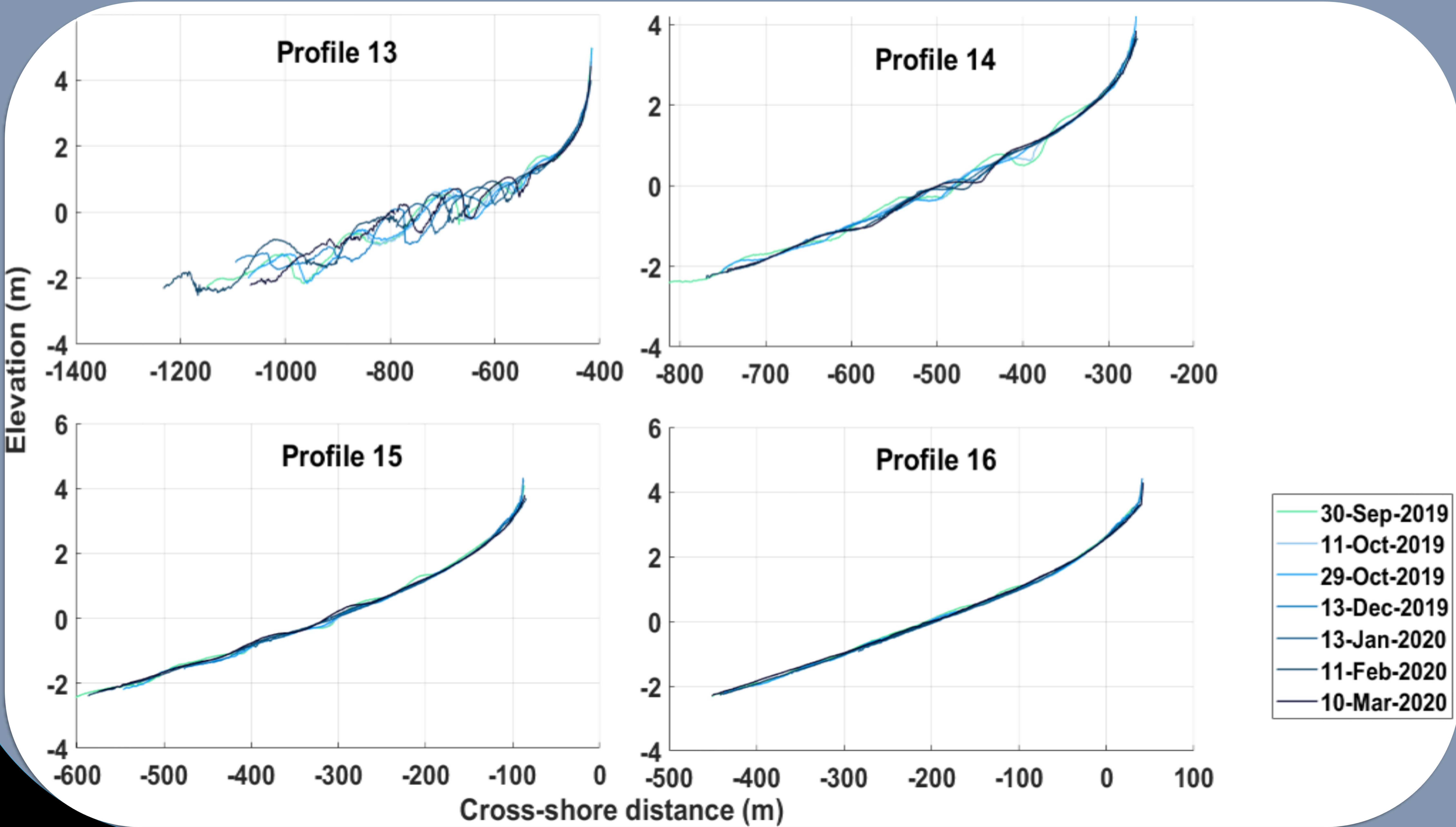
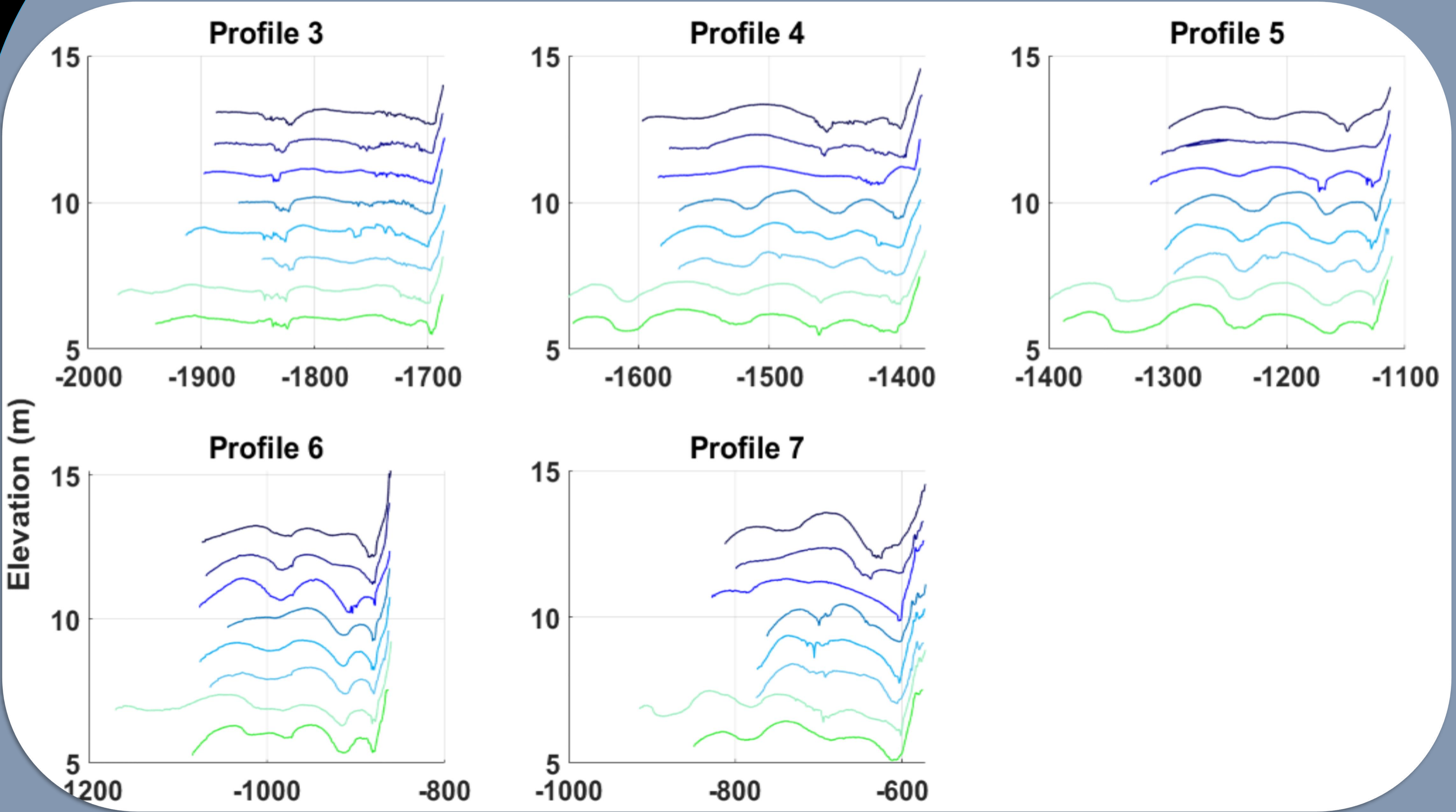


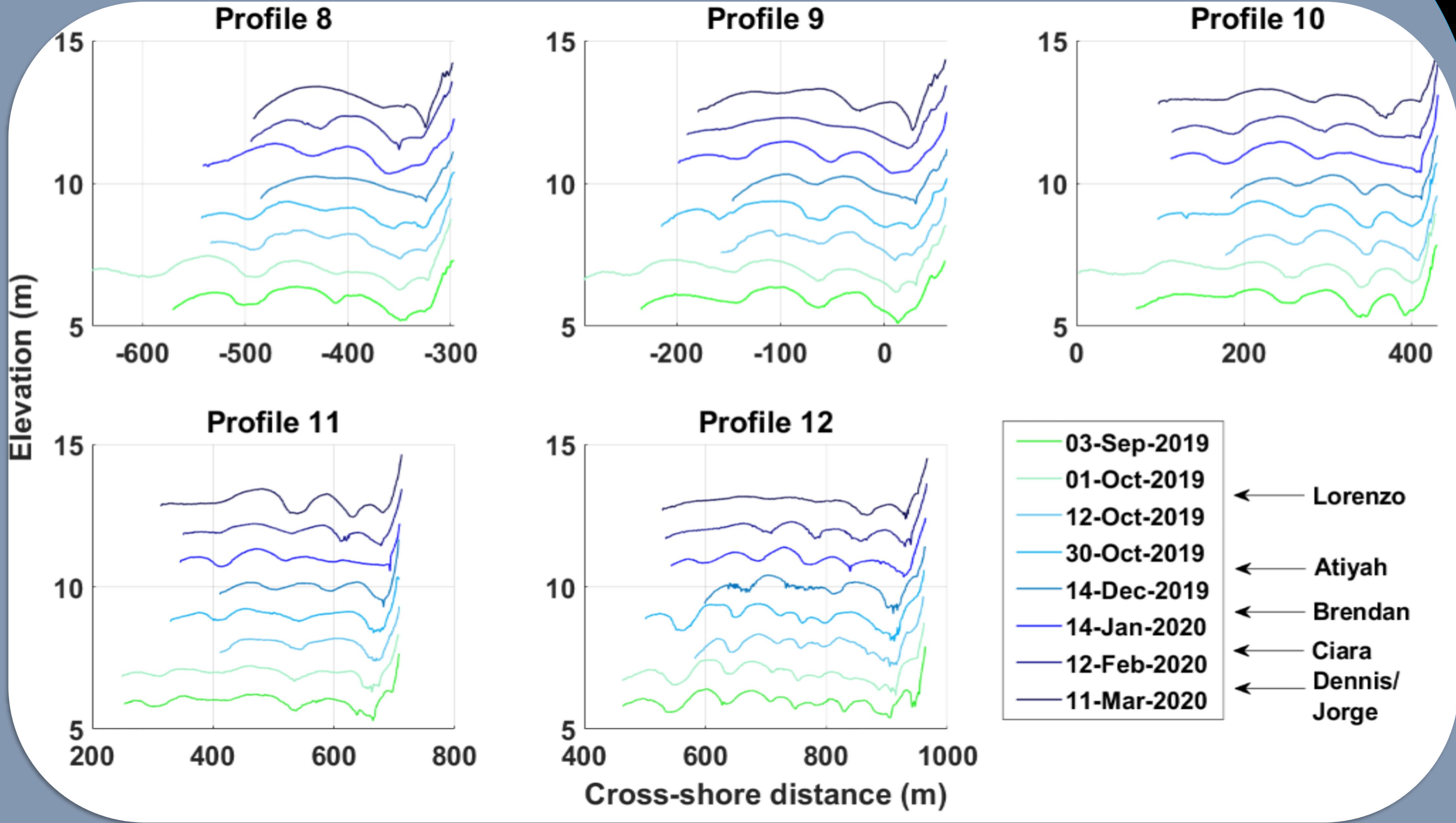
- Morphological differences measures between September the 30th and March the 10th
- Cross-shore erosion/accretion sequencing between -200 and -400 m cross-shore distance
- Cross-shore migration of the most landward bar according to mean profiles
  - P13: stable until Dec., migrations and changes in shape and amplitude the rest of the season
  - P14: crests erosion until Dec., followed by onshore migrations and a stabilisation at the end of the season
  - P15: flattening of the profile in Jan./Feb., bars recovery in March
  - P16: flattening of the profile
- **Onshore migrations, crests erosion, profiles flattened**
- **Alongshore variability depending on the pre-seasonal morphology**

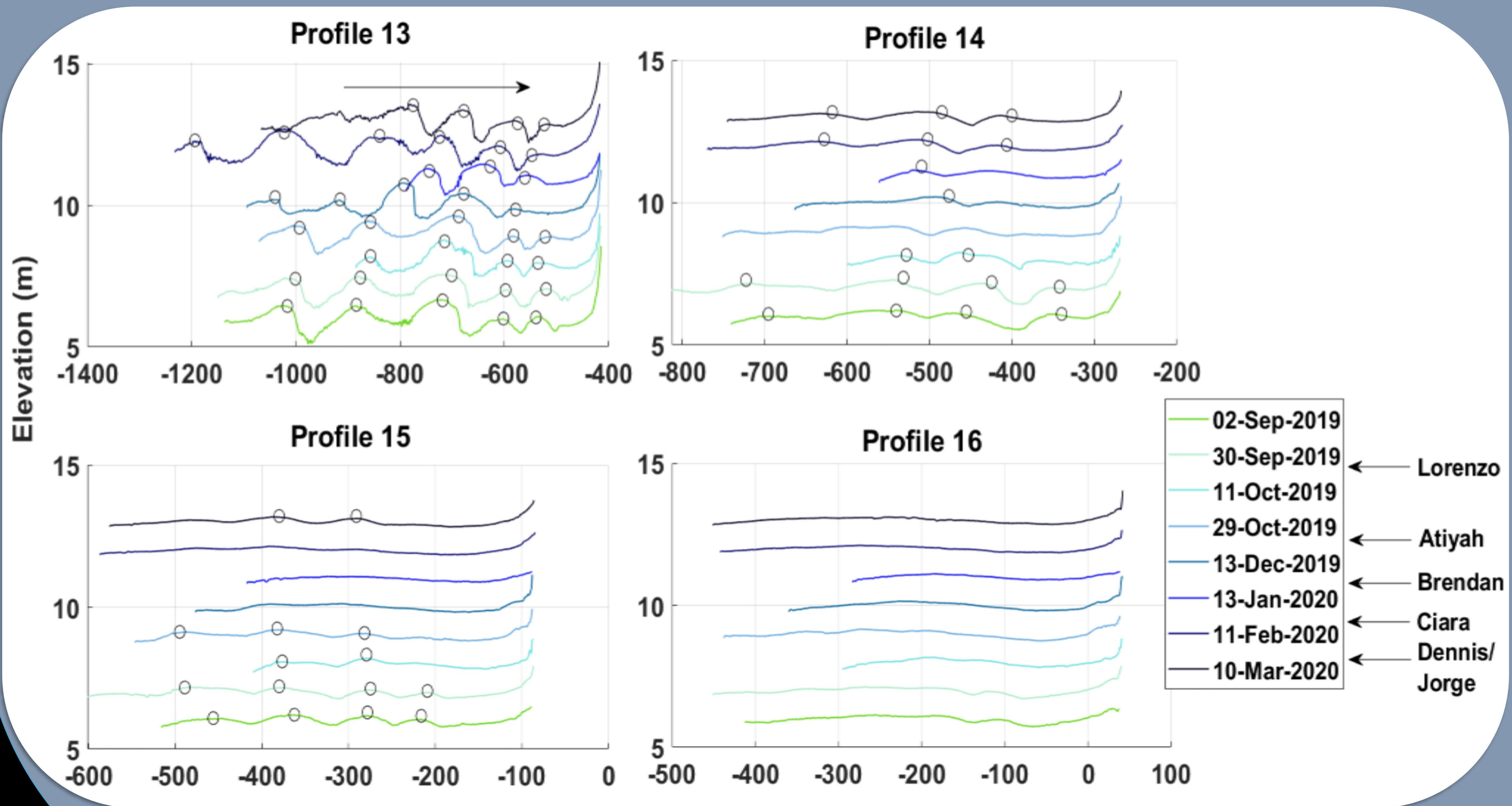


Results & Discussions

- Storm activities and impact on MITB







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Duration (Hrs)		15	18	30	48	18
Storm Power Index (Ps)		148	369	489	719	253

- Storm definition for Dundrum: Hs > 2,35 m for more than 15 hours
- Lorenzo not a real storm for our study site
- Brendan: the most energetic event, but Dennis: the longest event ➔ highest Ps
- **Same direction ➔ Potential diffraction/refraction in the bay due to nearshore bathymetry**
- **Impact of storm driven by the pre-storm morphology ➔ profile eroded seem to recover after the next storm**
- **Storm- generated erosion: mostly concern the upper system (landward bar) ➔ role of the tide?**
- **Energetic events ➔ Erosion of bar crests and/or onshore migration**
  ➔ Possible recovery depending on pre-storm morphology
  ➔ High alongshore variability: nearshore bathymetry, bars: number and shape

Conclusions

- Seasonal morphological changes of MITB features:
  - ❖Summer:
    - ➢Increase in pre-existing bar amplitudes or formation of ridges
    - ➢Onshore bar migrations mostly observed, but high alongshore variability in MITB response to the summer season
  - ❖Winter:
    - ➢Erosion and onshore migrations of bar crests, flattened profiles, but high alongshore variability
    - ➢Mostly driven by energetic events and pre-seasonal morphology

➔Summer: 'healthy' MITB features
➔Winter: erosion/flattening of MITB features

- Event scale:
  - ❖Storm conditions: energy, diffraction/refraction, duration
  - ❖Pre-storm profile morphology ➔ Strong alongshore variability: crests erosion, bars migration, recovery
  - ❖Bars shape and number

➔ Alongshore variability: the role of nearshore bathymetry and pre-storm morphology
➔ Cross-shore variability: the role of tidal range and MITB morphodynamics

Perspectives

- ➢ Quantify crest migration rates and shape/amplitude changes of bars
- ➢ Look at the impact of tidal moments on the beach response to events
- ➢ Pursue field measurements
- ➢ Modeling of the wave energy dissipation to investigate the alongshore variability of the system

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