NSW Coastal Conference

Collaborative research to understand sea level rise around South Korea using cutting-edge techniques

Dr Phil Watson
Honorary Research Fellow (CERF – JCR)
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Outline of Presentation

Context
General introduction to sea-level rise (SLR)
Cutting-edge analysis techniques for SLR
Available data sources in South Korea
Key results and their implications for South Korea
Augmenting current knowledge

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Context

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Context

South Korea …. Interesting facts

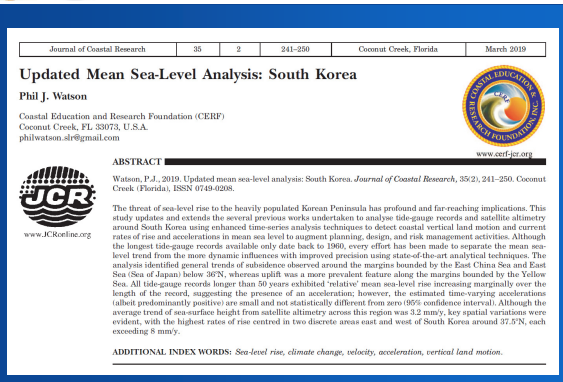
- Seoul (Capital)
- Population ≈ 51.5M (2019)
- Area ≈ 100.2 km^2 (1.5 X size of Tasmania)
- Comprised of 3,358 officially named islands
- Most technologically advanced country in the world
- 12th largest economy in the world (2019)

South Korea…many challenges for sea level rise

Context

- In May 2018, I was invited to deliver a keynote address at ICS2018 (Busan) on “Mean Sea Level Rise – Understanding and Measuring it better”
- At the instigation of Prof. Insik Chun (Konkuk University) and Dr. Hak-Soo Lim (KIOST), I undertook to apply more advanced analytical tools to South Korean ocean water level records
- The results of this work were published in the US Journal of Coastal Research in March 2019

Context



Journal of Coastal Research	35	2	241–250	Coconut Creek, Florida	March 2019

Updated Mean Sea-Level Analysis: South Korea

Phil J. Watson

Coastal Education and Research Foundation (CERF)
Coconut Creek, FL 33073, U.S.A.
philwatson.slr@gmail.com

www.cerf-jcr.org

www.JCRonline.org

ABSTRACT

Watson, P.J., 2019. Updated mean sea-level analysis: South Korea. *Journal of Coastal Research*, 35(2), 241–250. Coconut Creek (Florida), ISSN 0749-0208.

The threat of sea-level rise to the heavily populated Korean Peninsula has profound and far-reaching implications. This study updates and extends the several previous works undertaken to analyse tide-gauge records and satellite altimetry around South Korea using enhanced time-series analysis techniques to detect coastal vertical land motion and current rates of rise and accelerations in mean sea level to augment planning, design, and risk management activities. Although the longest tide-gauge records available only date back to 1960, every effort has been made to separate the mean sea-level trend from the more dynamic influences with improved precision using state-of-the-art analytical techniques. The analysis identified general trends of subsidence observed around the margins bounded by the East China Sea and East Sea (Sea of Japan) below 36°N, whereas uplift was a more prevalent feature along the margins bounded by the Yellow Sea. All tide-gauge records longer than 50 years exhibited 'relative' mean sea-level rise increasing marginally over the length of the record, suggesting the presence of an acceleration; however, the estimated time-varying accelerations (albeit predominantly positive) are small and not statistically different from zero (95% confidence interval). Although the average trend of sea-surface height from satellite altimetry across this region was 3.2 mm/y, key spatial variations were evident, with the highest rates of rise centred in two discrete areas east and west of South Korea around 37.5°N, each exceeding 8 mm/y.

ADDITIONAL INDEX WORDS: *Sea-level rise, climate change, velocity, acceleration, vertical land motion.*

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- The published results have been further updated for today's presentation

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Augmenting current knowledge

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Introduction to sea level rise…

Ocean water levels in any location will be principally governed by 2 key classes of influencing phenomena

- **Type 1 influence:** change the ocean water surface by pushing it up and down, but, do not change the mass of the ocean (dynamic influences)
- **Type 2 influence:** directly change the mass of the ocean and are largely very long cycle influences (detected as changes in the trend of mean sea level over time)

Introduction to sea level rise…

Type 1 influences include:

- Seasonal processes
- Tidal harmonics (up to ≈ 18.6 years)
- Pole tide (annual and ≈ 433-day signal)
- Global and regional climate modes
- Storm influences (storm surge and waves)
- Long period waves (e.g., Rossby, shelf waves)
- Fluctuations in ocean currents
- Quasi 60-year ocean oscillation
- Others…

Introduction to sea level rise…

Type 2 influences include:

- Long timescale solar cycles (Milankovitch ≈ 120kyr)
- Anthropogenic climate change (post ≈ 1750)

Both processes lead to global sea level rise through melting of snow and ice reserves and thermal expansion of the ocean water mass.

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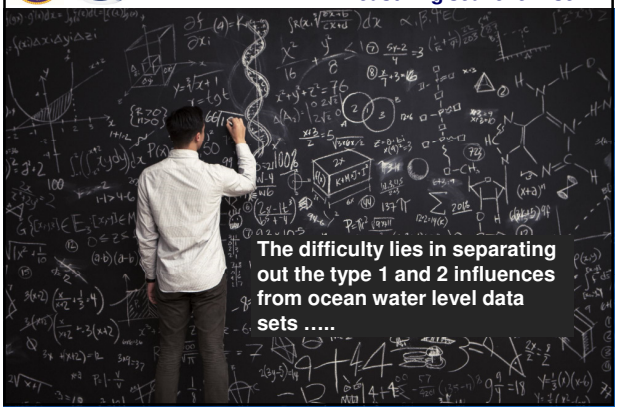
In measuring sea level rise…

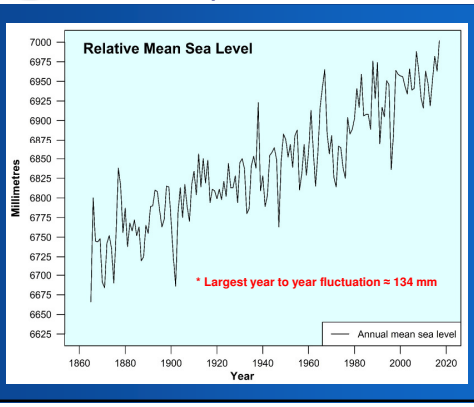


Cutting-edge analysis techniques for SLR…

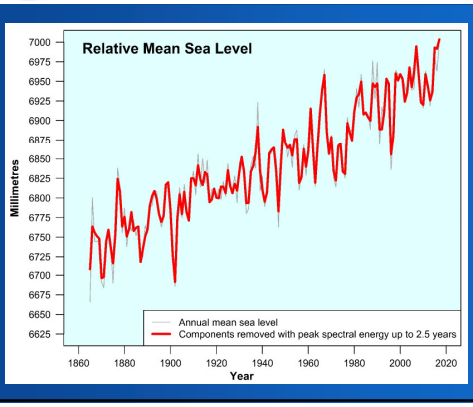
Analysis principally involves 3 key steps:

- Application of advanced data adaptive spectral techniques which enable type 1 and 2 signals to be separated with confidence

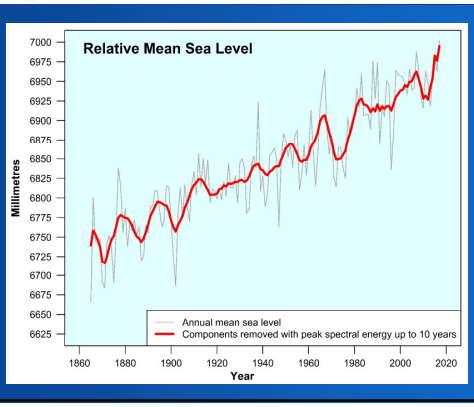
Example: Den Helder, North Sea



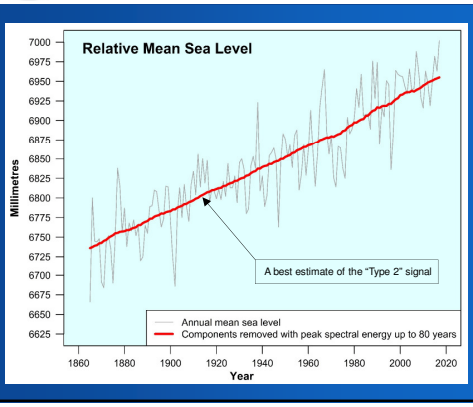
Den Helder, North Sea



Den Helder, North Sea



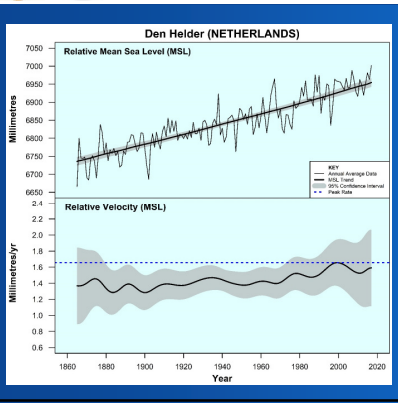
Den Helder, North Sea



Cutting-edge analysis techniques for SLR…

Analysis usually involves 3 key steps:

- Application of advanced data adaptive spectral techniques which enable type 1 and 2 signals to be separated with confidence
- Fitting a smoothing spline to the "type 2" signal permits estimating the time varying velocity and acceleration of mean sea level at each time step



Analysis: "TrendSLR" Package in R

Cutting-edge analysis techniques for SLR…

Analysis usually involves 3 key steps:

- Application of advanced data adaptive spectral techniques which enable type 1 and 2 signals to be separated with confidence
- Fitting a smoothing spline to the "type 2" signal permits estimating the time varying velocity and acceleration of mean sea level at each time step
- Consideration of the influence of any vertical land motions where tide gauge records are used

Land motion directly measured (GNSS)

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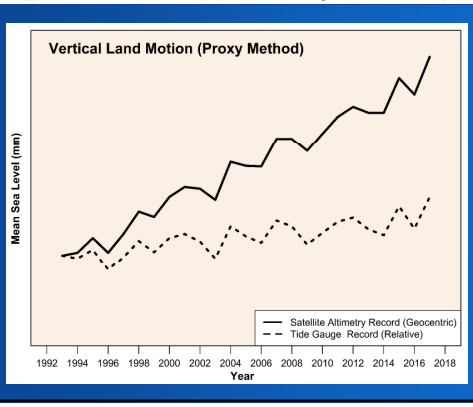
Land motion indirectly measured (ALT-TG)



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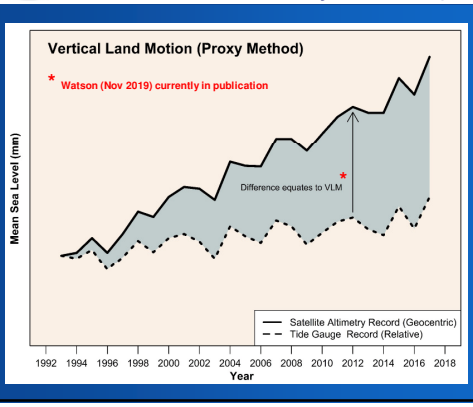
Land motion indirectly measured (ALT-TG)



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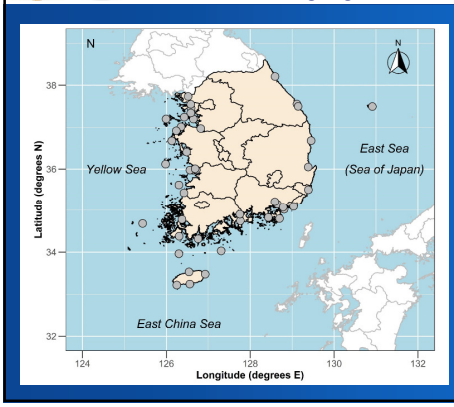
Tide gauge records



44 records
(42 active)

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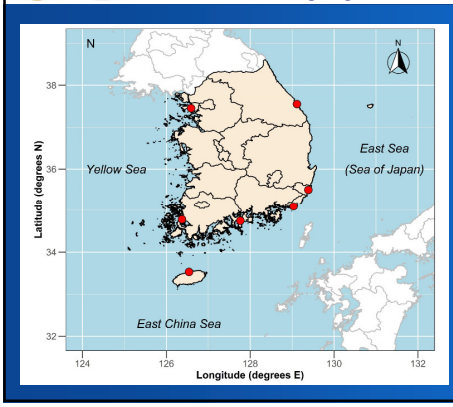
Tide gauge records



> 50 years
(7 active)

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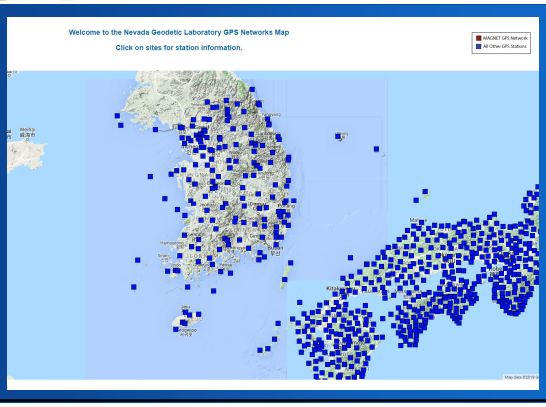
GNSS Stations



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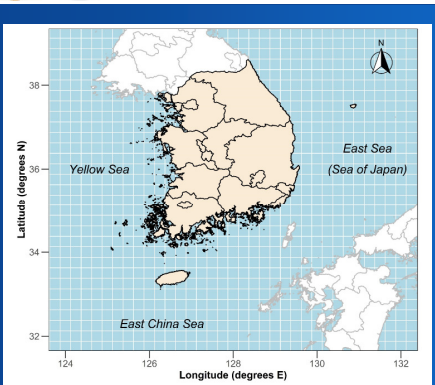
GNSS Stations

Of the GNSS stations available around South Korea within proximity to the 21 tide gauge stations active over the satellite altimetry era (post 1993):

- 7 are within 5km, 3 have records longer than 5 years
- 2 are within 1km, both records < 5 years
- None co-located with a tide gauge
- Limited direct value for sea level research (at this point in time)

Gridded satellite altimetry data



Daily

0.25° x 0.25°

1/1/93 – 23/9/18

Supplier: CMEMS

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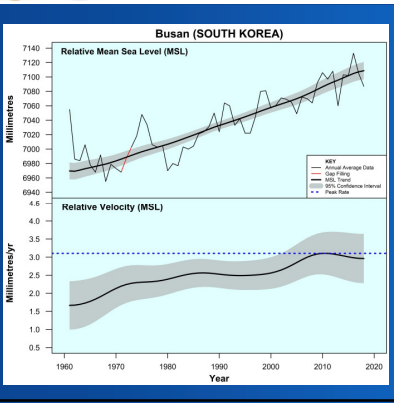
Busan Results

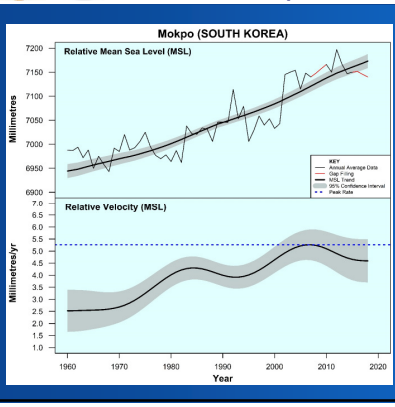


Data: PSMSL

Analysis: "TrendSLR" Package in R

Population: ≈ 3.4M

Mokpo Results

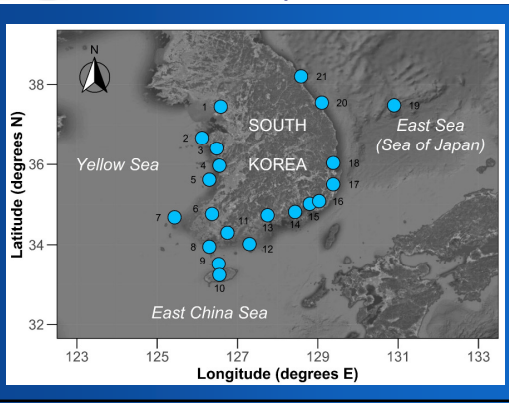


Data: PSMSL

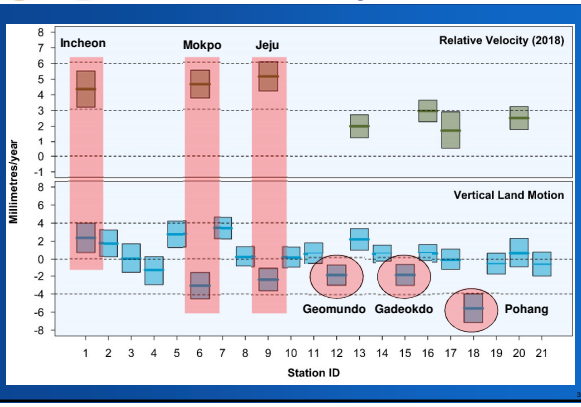
Analysis: "TrendSLR" Package in R

Population: ≈ 250K

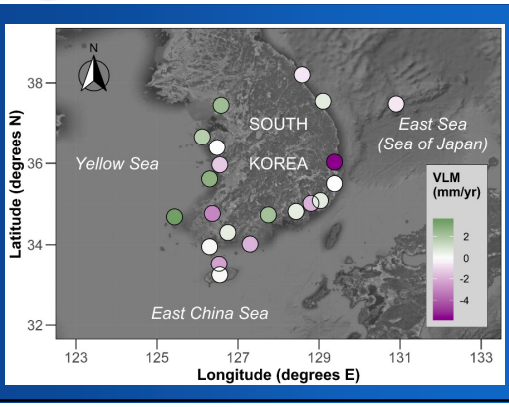
Station "ID" for presentation of results



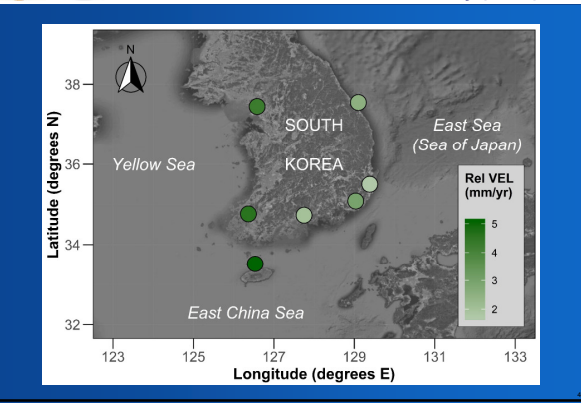
Areas of heightened risk from SLR



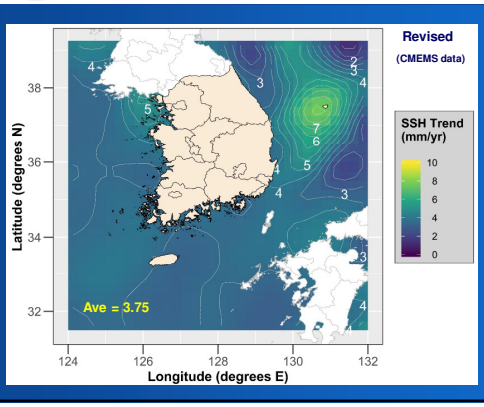
Vertical Land Motion



Relative Velocity (2018)



Satellite Altimetry Trends (Jan 1993 – Jan 2019)



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Key limitations of work to date

- The maximum-length data sets available for this analysis around the South Korean Peninsula are 58 years (1960 to 2018 at Incheon, Mokpo, and Busan), somewhat short of the optimal minimum lengths suggested for mean sea-level analysis
- Such records are not able to resolve (and therefore remove) such signals as the quasi-60-year ocean oscillation at the regional level, specific to South Korea
- The ALT-TG technique is only a proxy for VLM

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Augmenting current knowledge

Key research initiatives might include:

- Understanding the physical processes driving the high altimetry sea level trends at around 37.5° N both east and west of South Korea
- Installation of GNSS receivers co-located with tide gauges at key sites (critical long term investment)
- Understanding the processes that are contributing to high rates of subsidence in key coastal margins

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Augmenting current knowledge

Key research initiatives might include:

- Further training and knowledge sharing on sea level rise with KIOST, including use of the "TrendSLR" analysis package developed specifically for application to South Korean mean sea level records
- Extending analysis across Yellow Sea and to mainland China through collaboration with Korea – China Joint Ocean Research Center (suitable for publication in *Ocean and Polar Research*)

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Augmenting current knowledge

Key research initiatives might include:

- Determining how best to utilise results to inform strategic planning, adaptation planning and design purposes into the future
- Developing a national annual SLR web-based reporting system

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Acknowledgements

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- Korea Institute of Ocean Science and Technology
- Korea Hydrographic And Oceanographic Agency
- Korean Society of Coastal Disaster Prevention

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Thank you

감사합니다

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