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CPD PROGRAM: GLOBAL SURVEYORS DAY 2022

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The Potential of Using Satellite Altimetry for Detecting Sea Level Changes in Brunei

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CONTENTS

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AIMS

- To investigate the potential of using satellite altimetry data for studying sea level changes in Brunei coastal area

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INTRODUCTION

- The rise of sea level change raised concerns to the earth's population
- Global sea level rise is accelarating incrementally over time in the last 25 years
- Two major factors:
  - Thermal expansion
  - Melting of glaciers and ice sheets

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OBJECTIVES & OUTCOMES

- Understand the basic and fundamental concepts of satellite altimetry
- Review on previous study
- How altimetry data been used and challenges
- Data plotting using Phyton Programming software from Jason-1 and Jason-2 mission
- Data assessment with recommendations on the reliability of the data

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HOW SEA LEVEL CAN BE DETERMINED?

- Tide Gauge and Global Navigation Satellite System (GNSS) – effected by vertical land motion (VLM)

- Satellite Altimetry – satellite-based technology with reference to earth's center (independent)

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FACTORS OF SEA LEVEL CHANGES

- Thermal Expansion – rise in sea surface temperature (Ocean warmed by 0.009°C to 0.13°C per decade (IPCC, 2014))
- Sea level rise in coastal area due to tides and storm surge
- Vertical Land Motion
- Thermohaline Circulation – water density increased due to temperature and salinity

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GLOBAL SEA LEVEL TREND

- Rise of sea level concerned the world's population especially in the coastal areas
- Sea level rise can cause flooding, faster rate of erosion of cliffs and beaches and permanent submersion
- Sea level predicted to keep on rising in the next decade
- Global sea level rise at 1.6mm-1.8mm per year (tide gauge)
- 3.2mm-3.4mm per year since 1992 (satellite altimetry)

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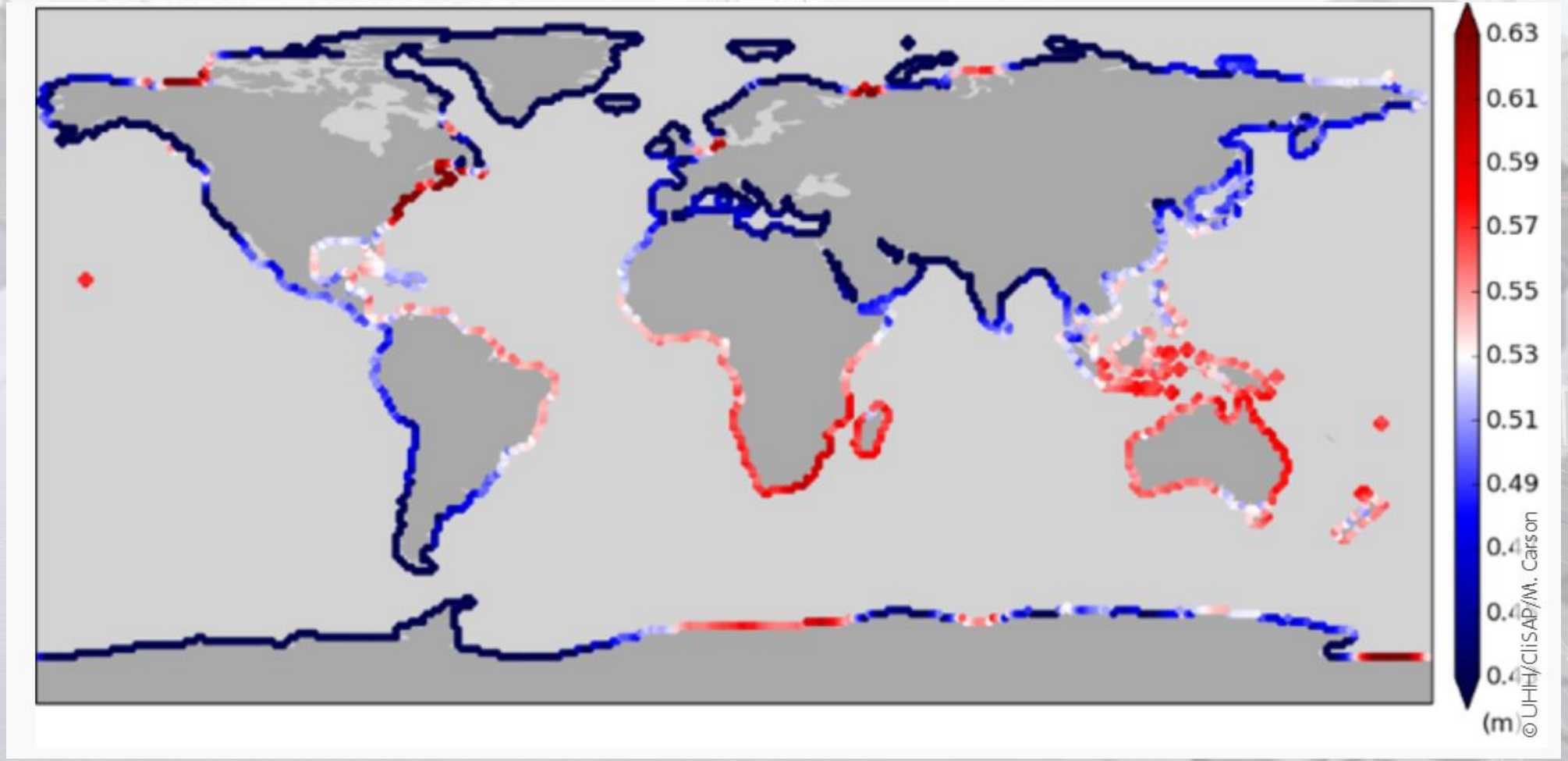
PREDICTED SEA SURFACE HEIGHT IN 2100



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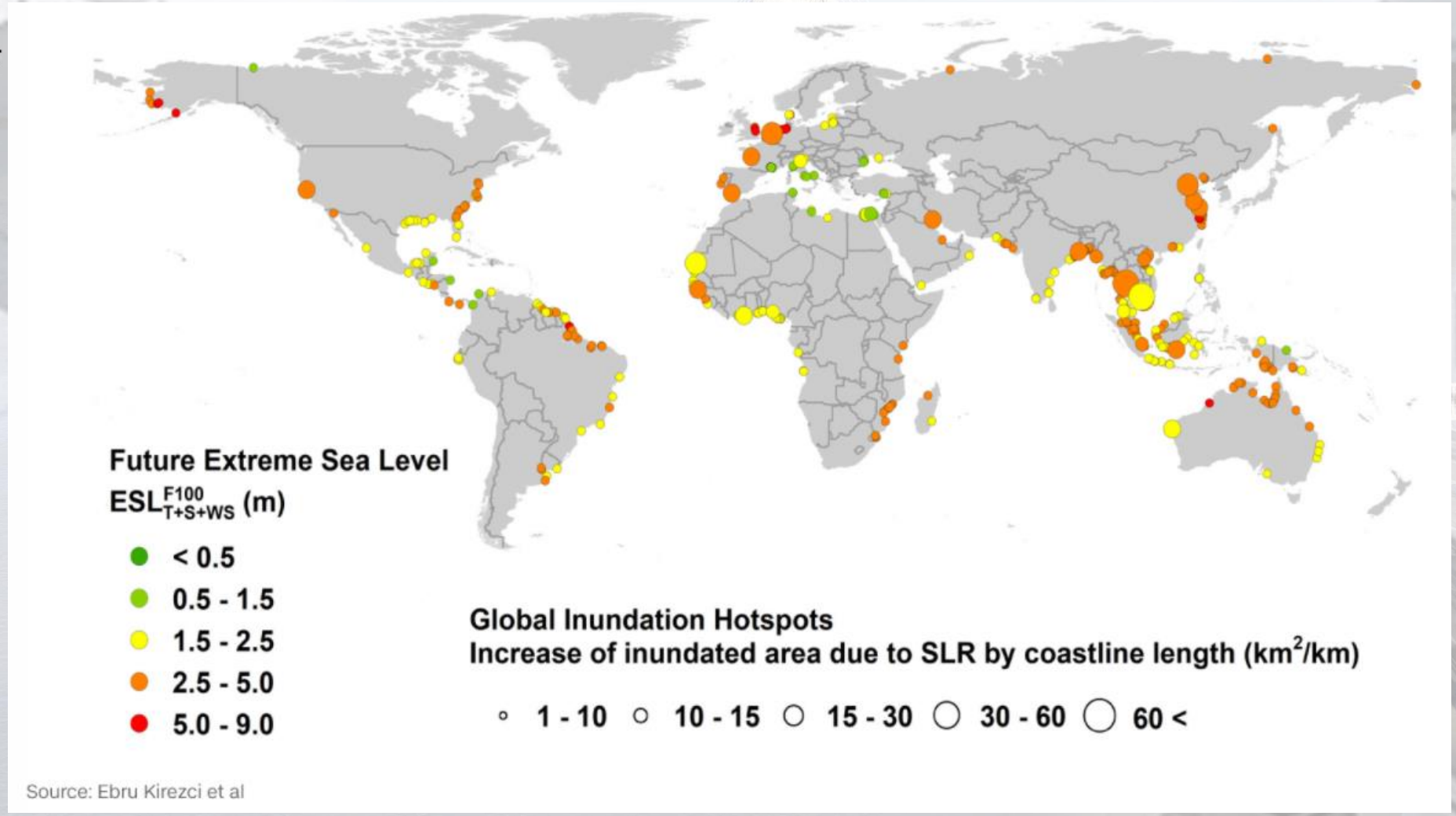
AREAS MOST AT RISK FROM EXTREME FLOODING BY 2100



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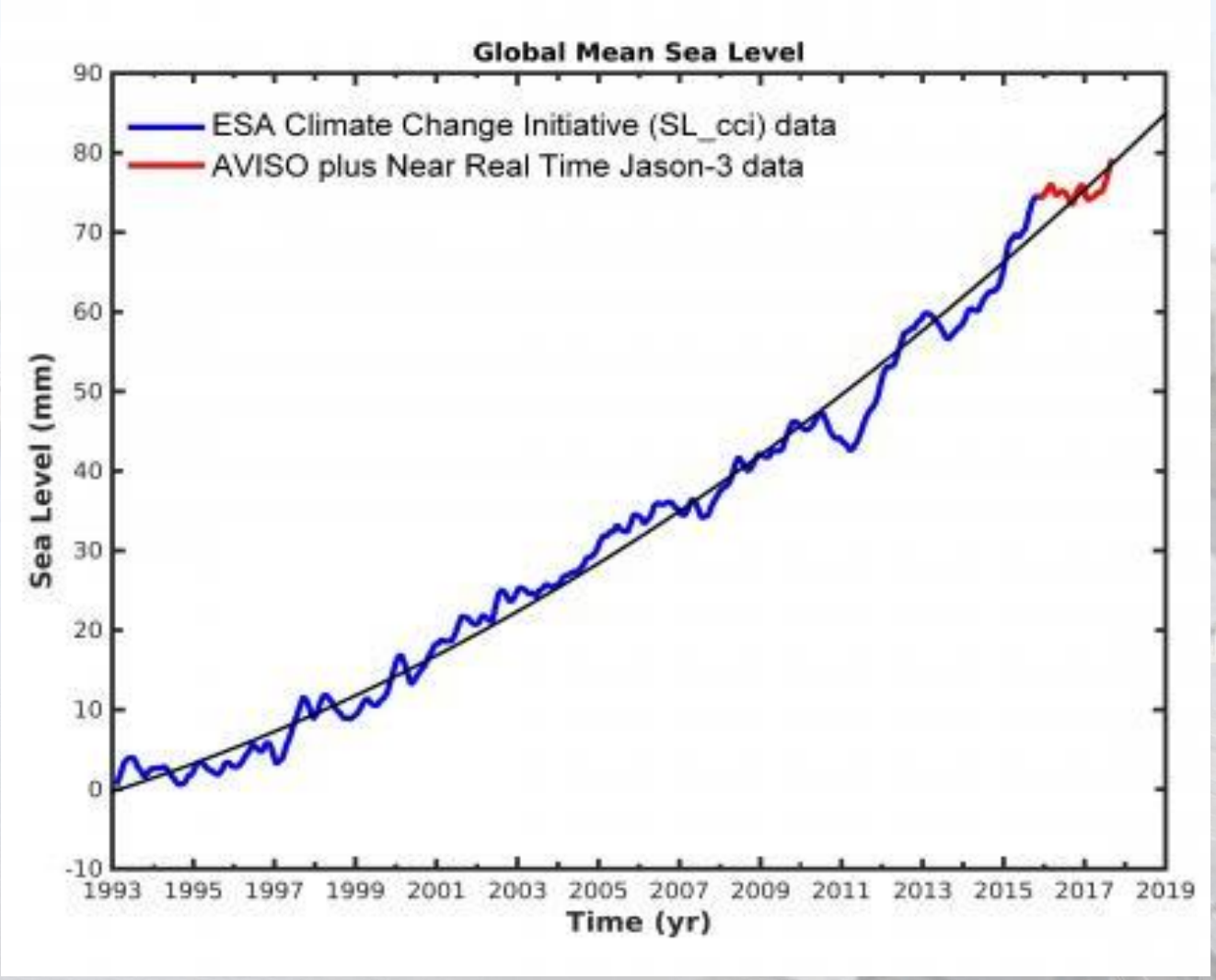
GLOBAL SEA LEVEL TREND



25 years of multi-mission sea level trend from altimetry (Source: ESA and CNES/LEGOS (AVISO), 2017)

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IMPORTANCE OF SEA LEVEL STUDIES

- Disaster mitigation plan

(Coastal flooding will become so extreme and destructive that it could cause damage worth up to 20% of global gross domestic product by 2100)

- Coastal management

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IMPORTANCE FOR BRUNEI DARUSSALAM?

- Geographical Location
- Industrial projects on islands and coastal region
- Long-term mitigation plan

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PREVIOUS STUDY IN SOUTH CHINA SEA

- World Bank Group published sea level anomaly for South China Sea based on T/P mission indicated a rise between 1992-2008
- Study by Li (2002) found there is a rise at the rate of 10mm/year with warming rate at 0.15°C/ year between 1993-1999
- Sea level fall in 1997-1998 due to El-Nino event (Cheng and Qi, 2007)
- Latest study by Hamid et.al (2016) indicated a rise at 3.85 mm/year (1993-2005) by using multi mission

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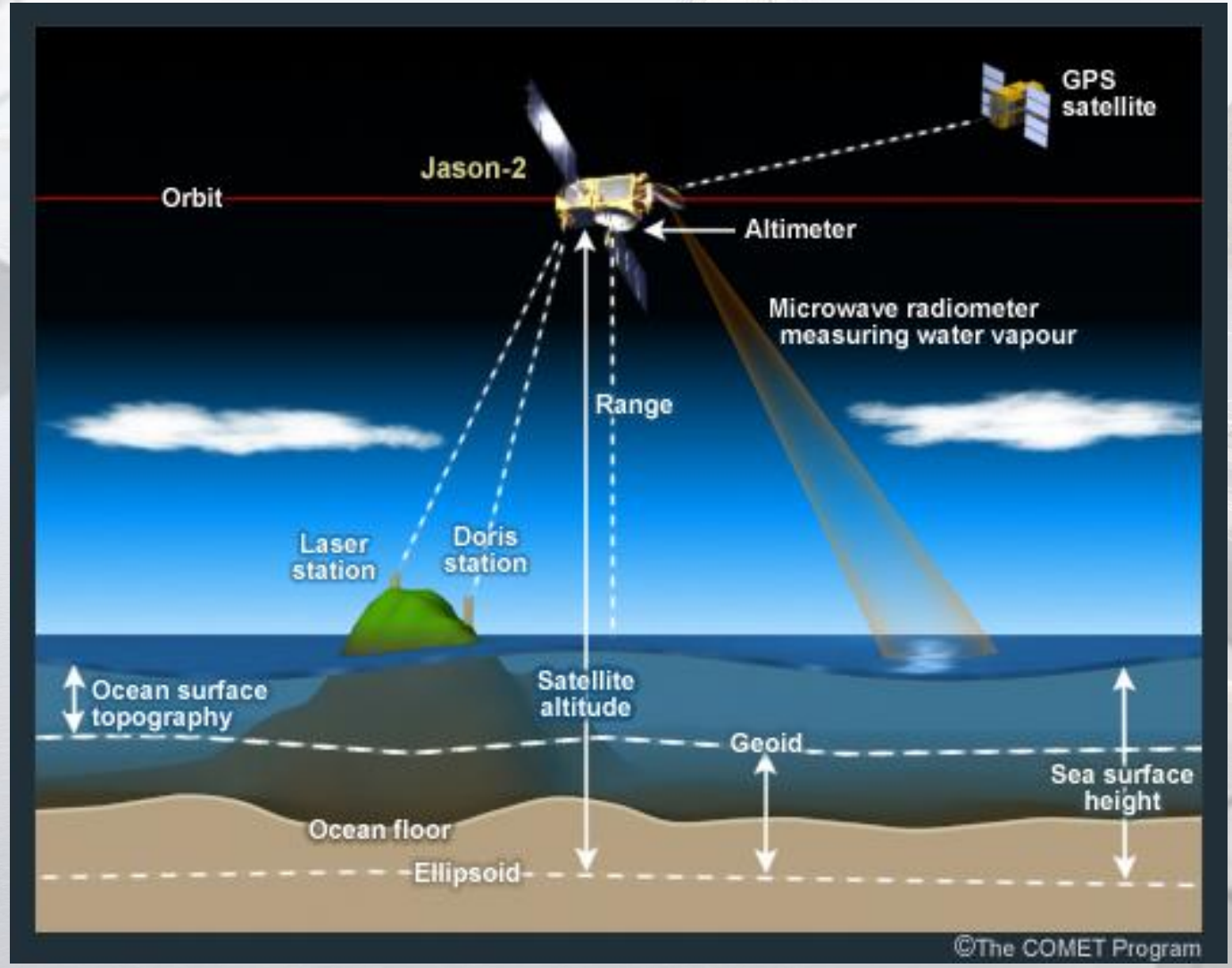
PRINCIPLES OF SATELLITE ALTIMETRY



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PRINCIPLE OF SATELLITE ALTIMETRY

- Measurement of time taken by a radar pulse to travel from satellite to the sea surface and back to the satellite
- Satellite location based on latitude, longitude and satellite altitude coordinates
  - GNSS Satellites
  - DORIS station
  - Satellite Laser Ranging (SLR)

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ERRORS AND CORRECTIONS

- Waves pass through the atmosphere can be decelerated by water vapour and inonisation
- Corrections:
  - Range corrections
  - Geophysical corrections – tides and atmospheric pressure

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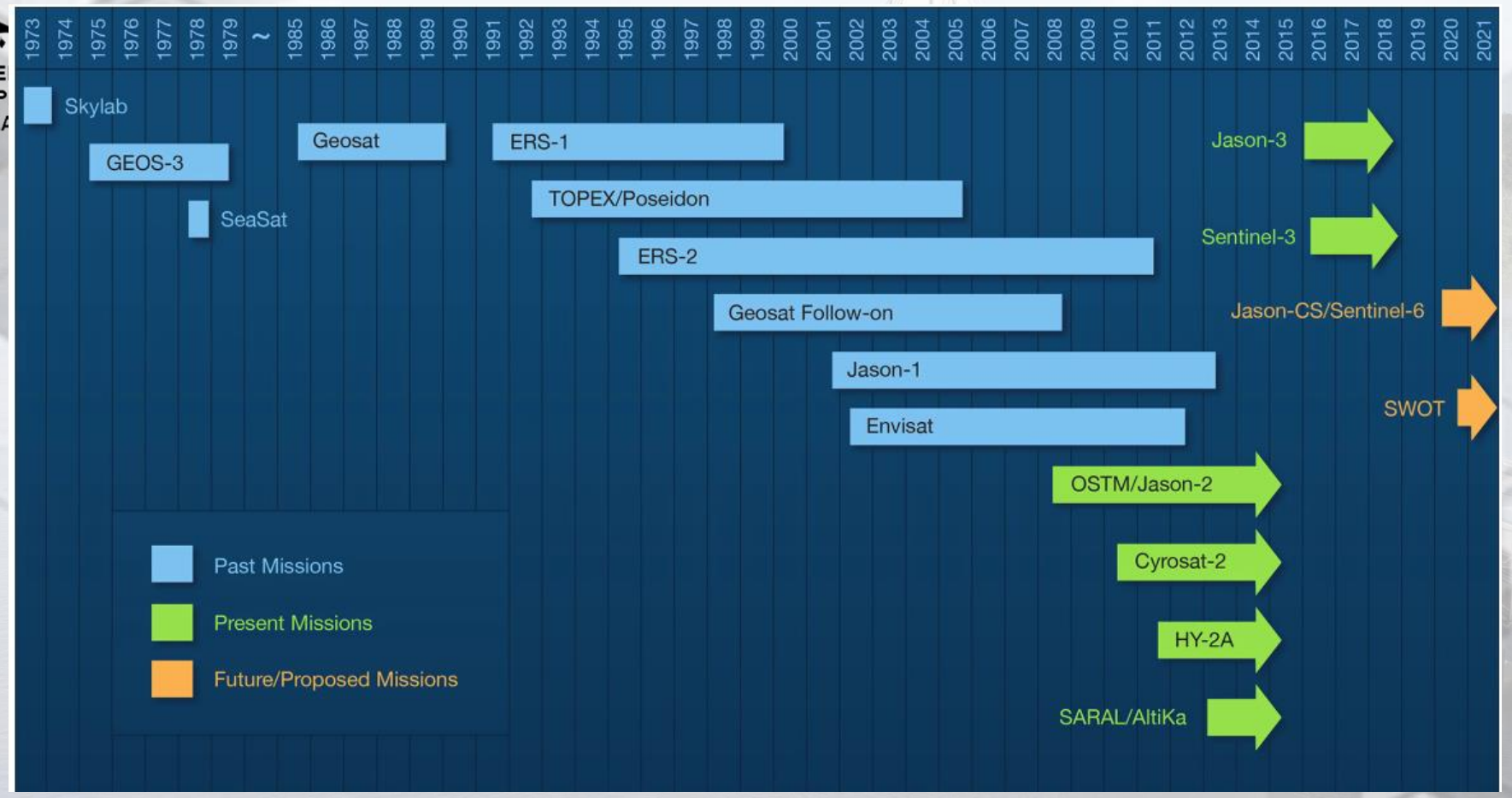
SATELLITE ALTIMETRY MISSION



@NASA JPL(2018)

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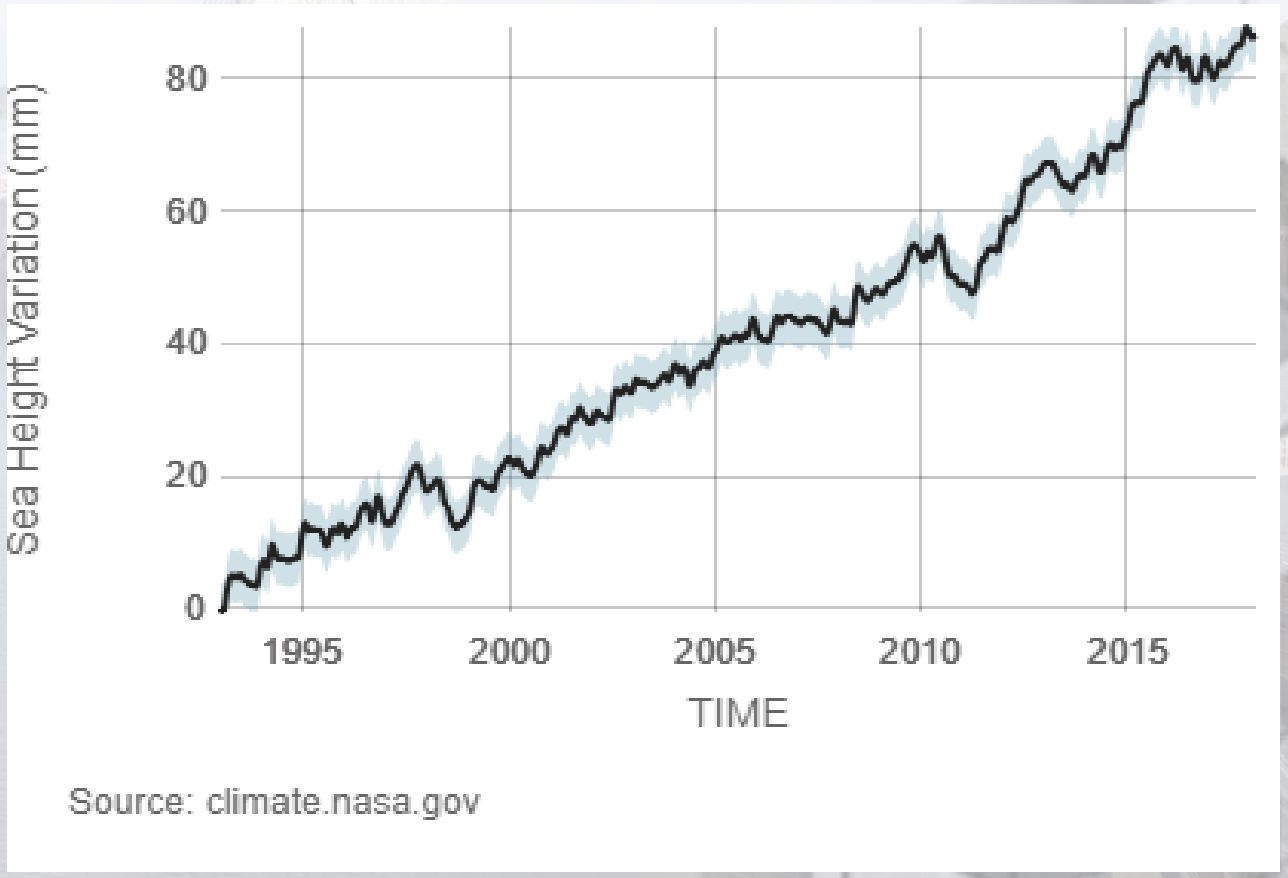
SATELLITE ALTIMETRY FOR SEA LEVEL

- Since 1992
- Better accuracy when compared to tide gauge – independent



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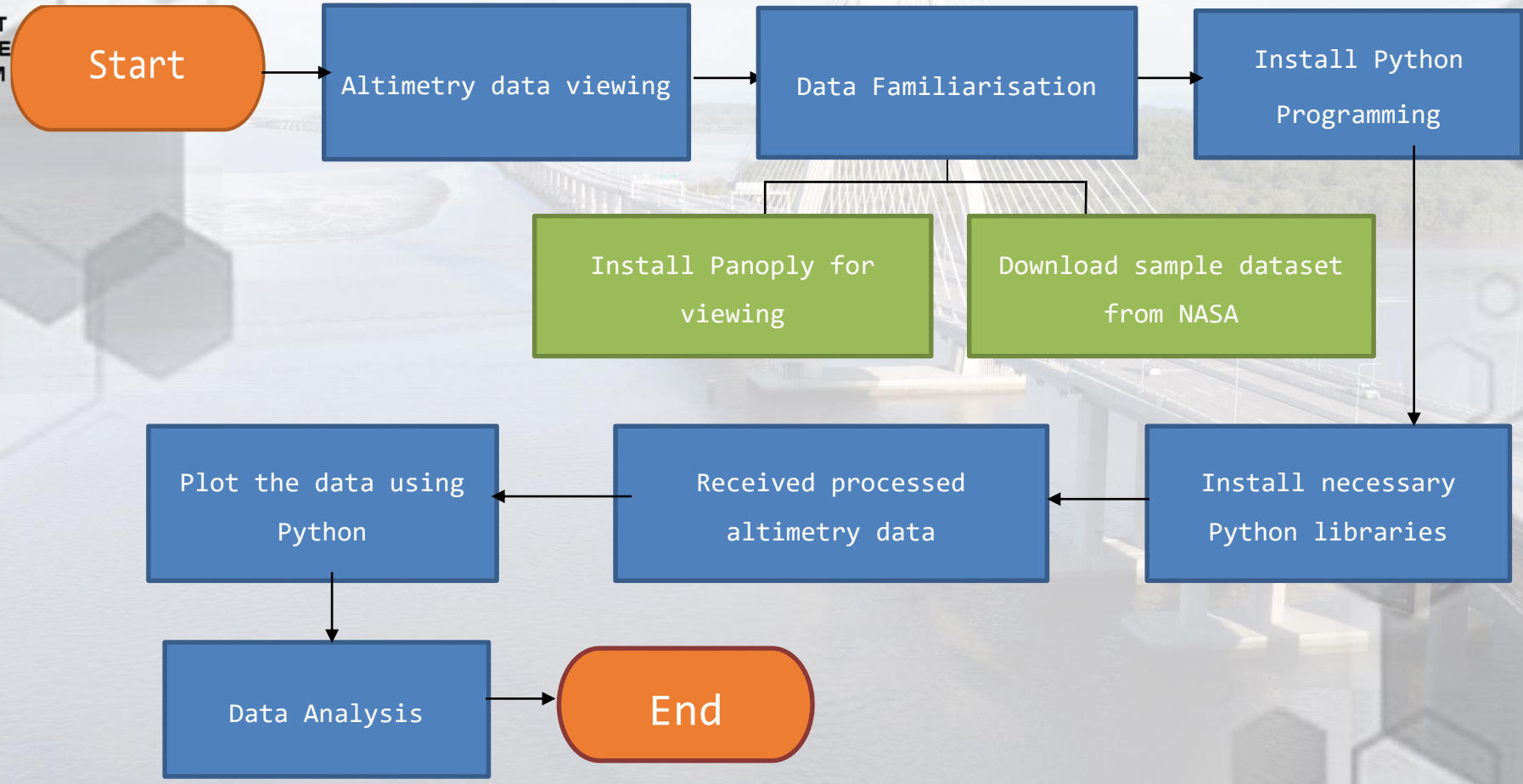
PROJECT OVERVIEW



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DATA SOURCE

- Geophysical Data Record (GDR) – AVISO
- Data contains sensor measurements and full set of geophysical corrections
- Two sets
  - Radar Altimetry Database System (RADS)
  - Sensor Geophysical Data Record (SGDR)
- Downloaded from NASA

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RADAR ALTIMETRY DATABASE SYSTEM (RADS)

- Provides simplification for reading, editing and handling
- Users able to access to the up-to-date range and geophysical corrections
- Consists of 1 Hz waveform – 1 point every 6 kilometres

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SENSOR GEOPHYSICAL DATA RECORD (SGDR)

- Full accuracy altimeter
- High precision orbit
- Accuracy approximately 1.5 cm
- Contains all relevant corrections for sea surface height calculation
- Include 20Hz waveform – 1 point every 300m

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DATA

- Processed data from Jason I and Jason II mission between 2002-2016
- Tracking path near Brunei coastline
- Jason mission tracks every 10 days during its mission
- Approximately 550 tracks

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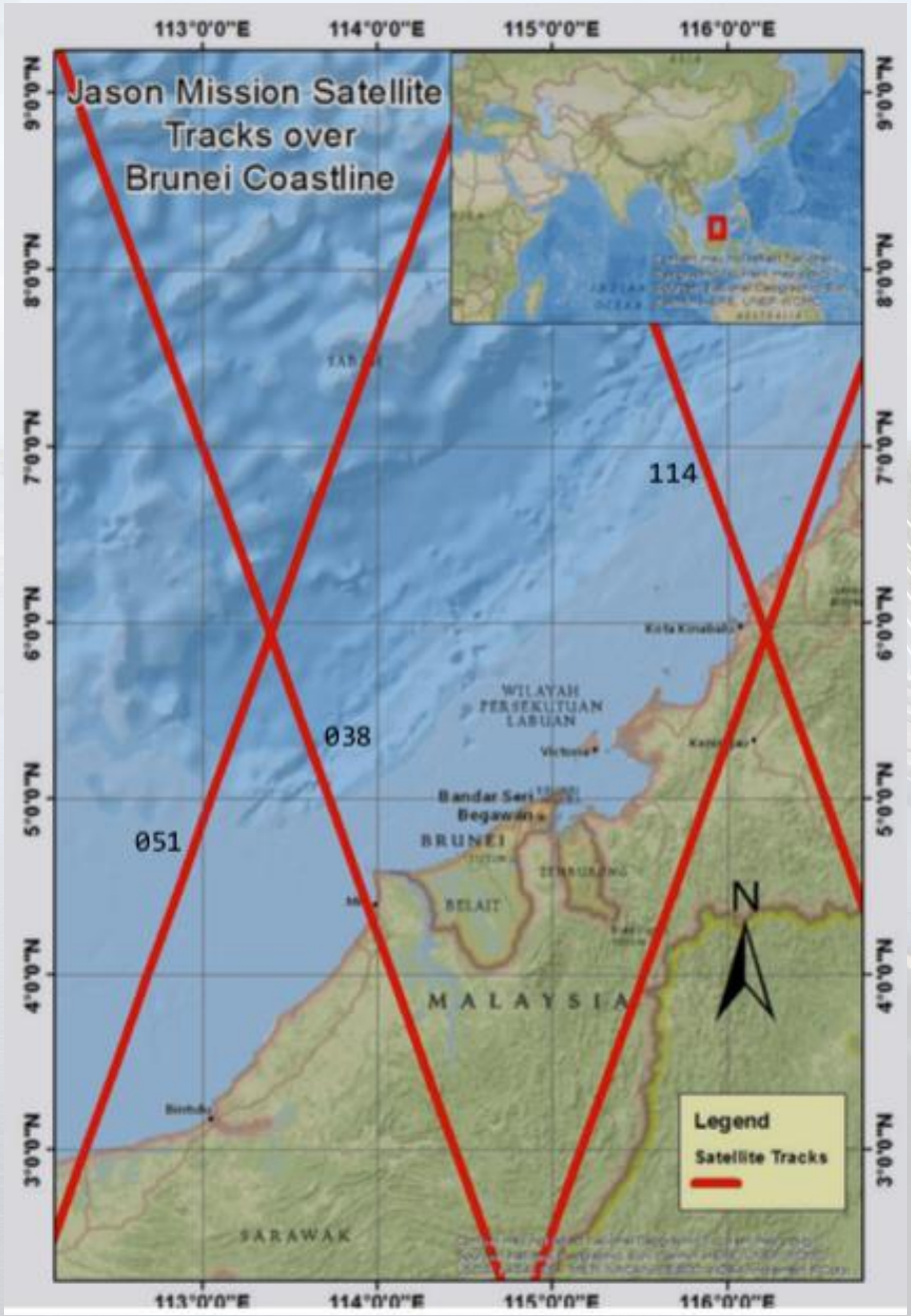

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DATA PROCESSING

- Processed by Dr Nadim Dayoub – National Oceanography Centre, Southampton
- Sea surface height processed relative to DTU15MSS model then computed using ALES retracker
- DTUMSS15? Latest release model for high resolution mean sea surface
- Time series sea level trend calculated using Robust Regression analysis

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DATA PLOTTING

- Time series sea level trend calculated using Robust Regression analysis
- Data in netCDF format
- Python programming – ability to handle and plot netCDF data

RESULTS AND ANALYSIS

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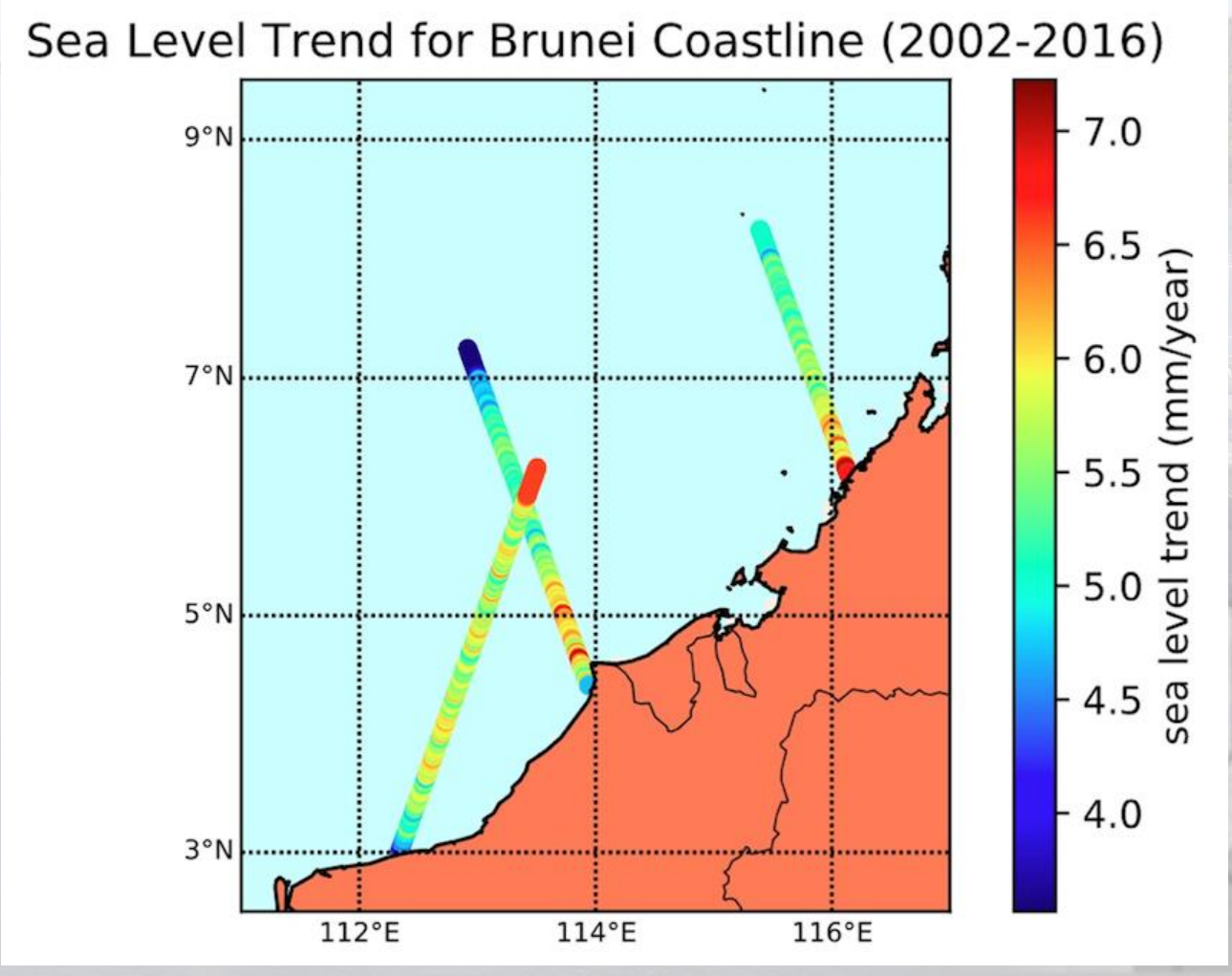
- Sea level trends from 2002-2016 from three satellite tracks near Brunei coastline



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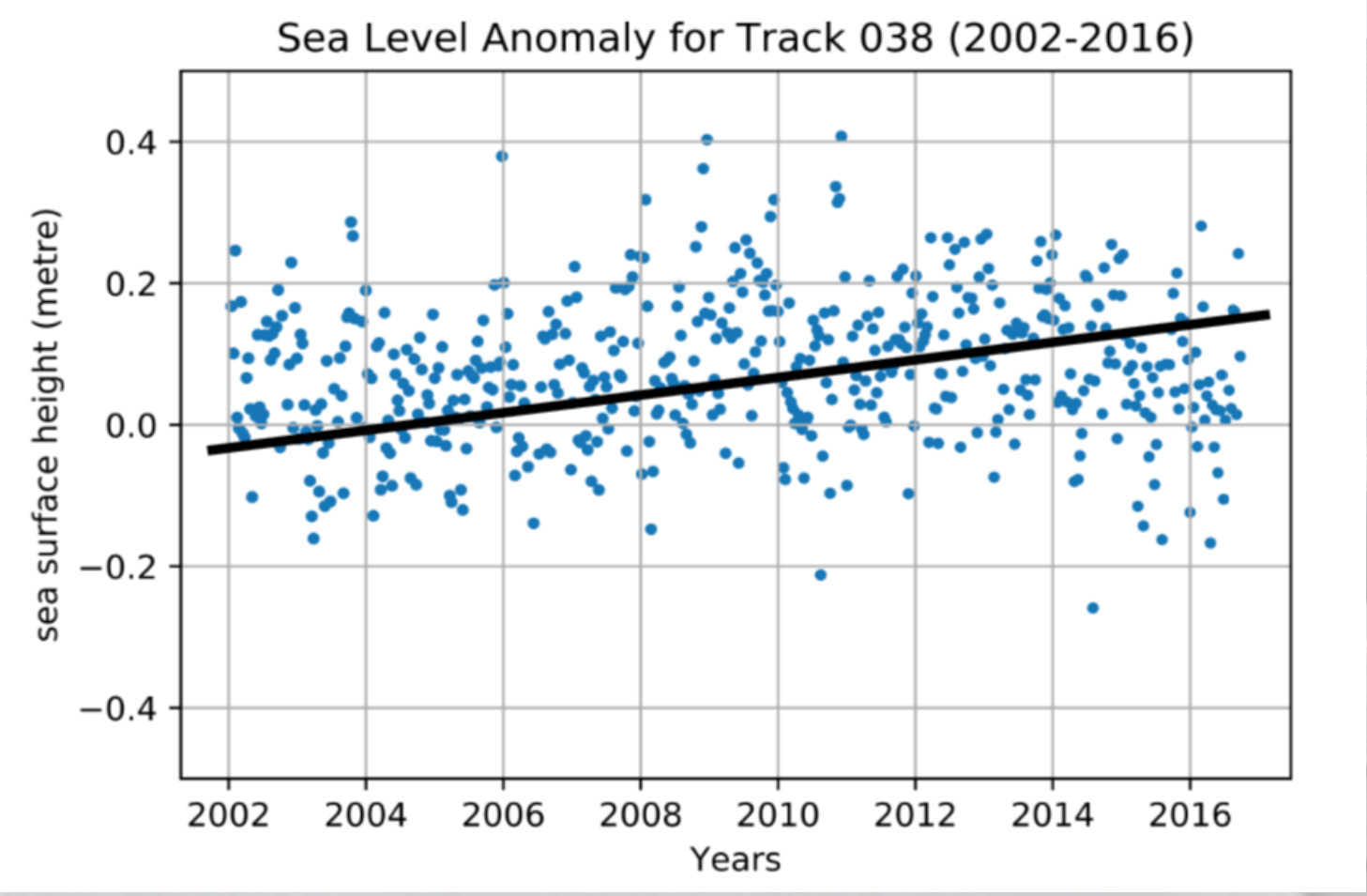
RESULTS AND ANALYSIS

- Average sea level trend rise at 5.5 mm/year



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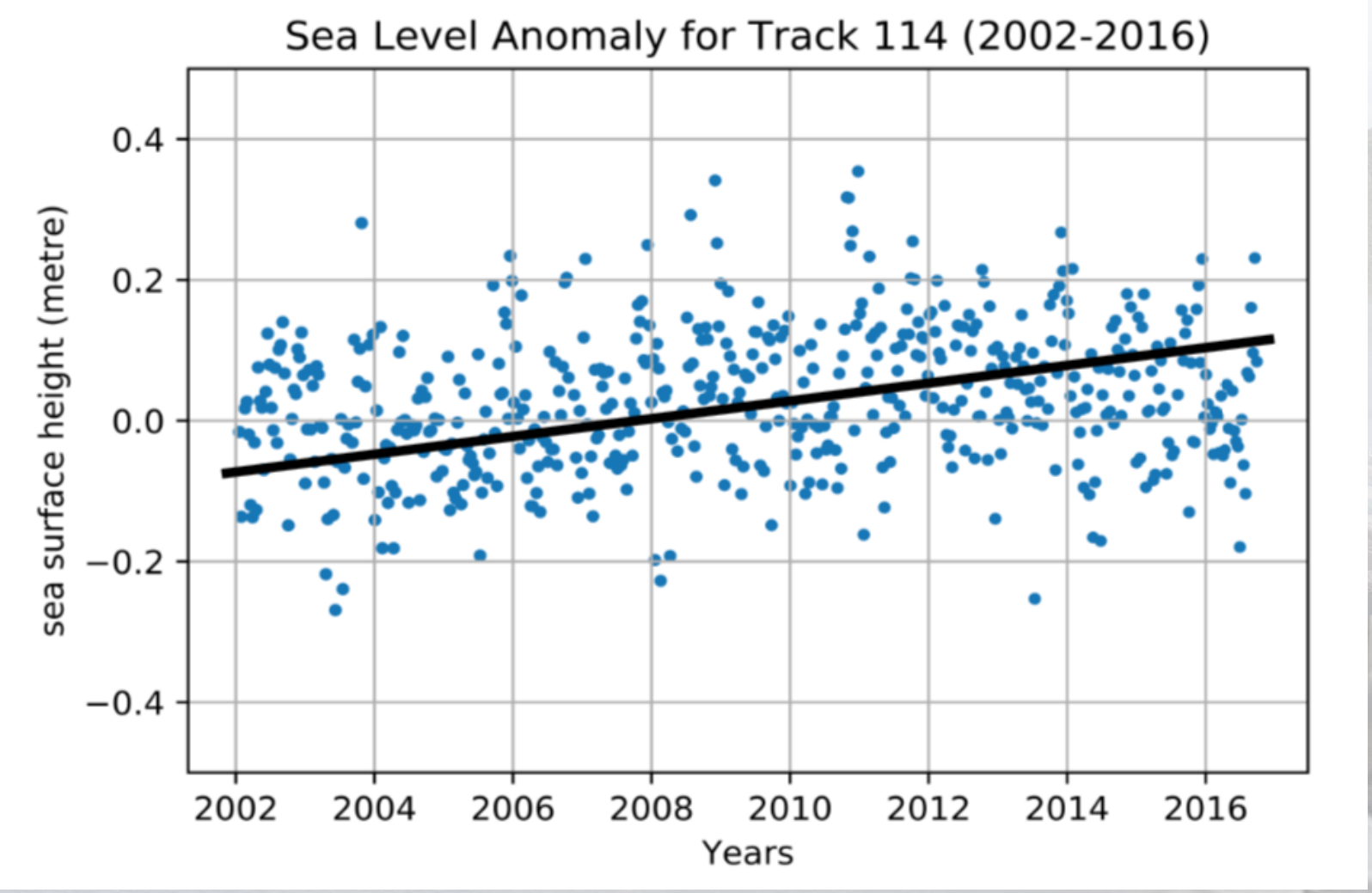
RESULTS AND ANALYSIS



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DISCUSSION AND RECOMMENDATION

- Sea Level Trend
  - The sea level trend in this project does agree with previous study
- Limitations
  - Extensive period can give clear indication of the trend
  - Satellite coverage not exactly at Brunei coastline
  - Errors as it approached the coastline

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FUTURE WORK

- Data validation against existing tide gauges – one tide gauge collected data since 1990
- Vertical land motion study – availability of tide gauges and GNSS
- Study of water level for rivers and lakes
- Sentinel-3 mission – extensive satellite coverage

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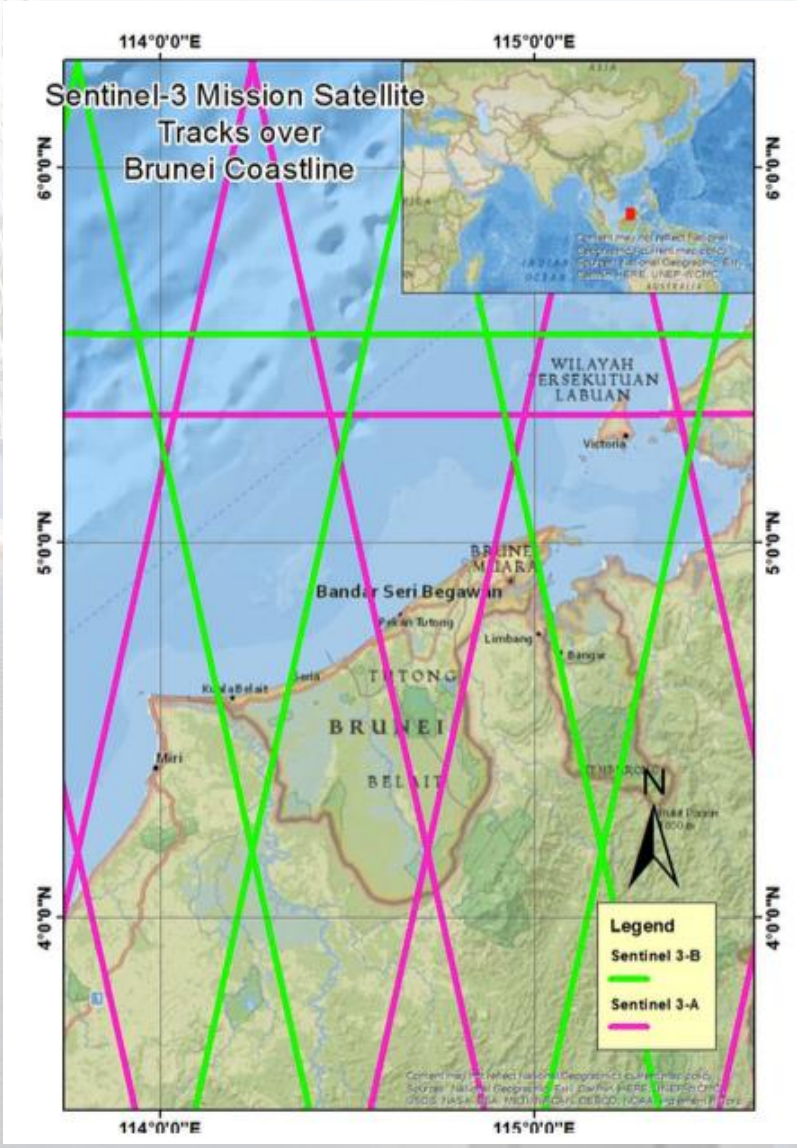
Sentinel-3 Satellite Coverage

FUTURE WORK – SENTINEL 3 MISSION

- First launched in 2016



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WAY FORWARD

- Sea level trend prediction in the next 10 years
- Information from this project – early mitigation plan
- Further investigation of sea surface temperature
- Altimetry data processing expertise

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CONCLUSION

- Study able to predict the sea level trend of Brunei Darussalam
- Sea level trend for Brunei Darussalam rising approximately at the rate of 5.5mm/year between 2002-2016
- Satellite altimetry has high potential for sea level study in Brunei Darussalam

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THANK YOU!

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