2023 Ocean Surface Topography Science Team (OSTST) meeting

Impacts of using different atmospheric models on altimeter-derived Sea Level Trends

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Outline

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Motivation

- In the context of satellite altimetry, numerical weather models (NWM) are relevant sources to derive the wet path delay (WPD) in the radar signal, mainly caused by the atmospheric water vapour. Over regions where WPD based on observations are not available, these may be the only source of information.
- ECMWF state-of-the-art models: Operational model (ECMWF OP) and reanalysis 5 (ERA5).
- The only model-derived WPD currently provided in most altimetric products is ECMWF OP.

➔ This study presents an assessment of the state-of-the-art NWM (ECMWF OP and ERA5), for estimating the WPD of satellite altimeter observations, with focus on the impacts on altimeter-derived sea level trends.

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Datasets

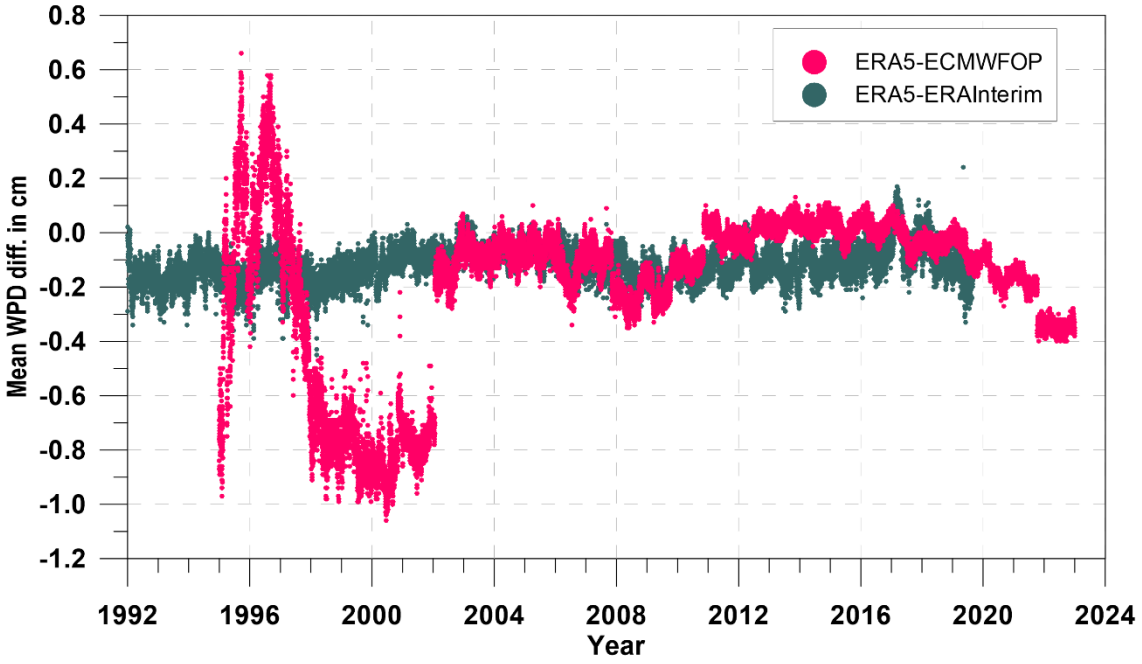
- **ECMWF models:**
  - ECMWF OP: 0.125ºx0.125º, 6 h intervals – operational model
  - ERA5: 0.25ºx0.25º, 1 h intervals – latest reanalysis, launched in July 2017
  - ERA Interim: 0.75ºx0.75º, 6 h intervals – previous reanalysis, discontinued in September 2019

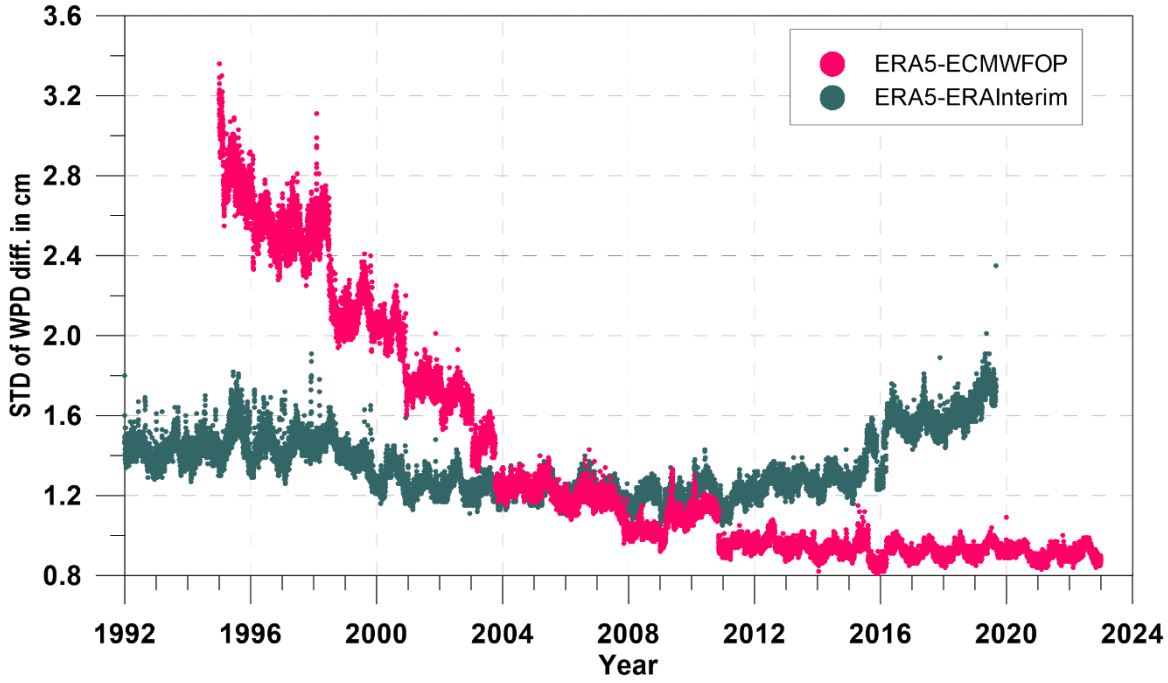
- **SSMIS:** Special Sensor Microwave Imager and Special Sensor Microwave Imager Sounder (SSMIS) – stable and calibrated radiometric reference for WPD estimation.

- **Altimeter data**: Sea level anomalies (**SLA**) for Jason-2, Jason-3 and Sentinel-3A from **RADS**.

Comparison between ERA5, ECMWF OP and ERA Interim (1992-2023)

Mean (left) and standard deviation (right) of WPD differences, in cm (global weighted values).

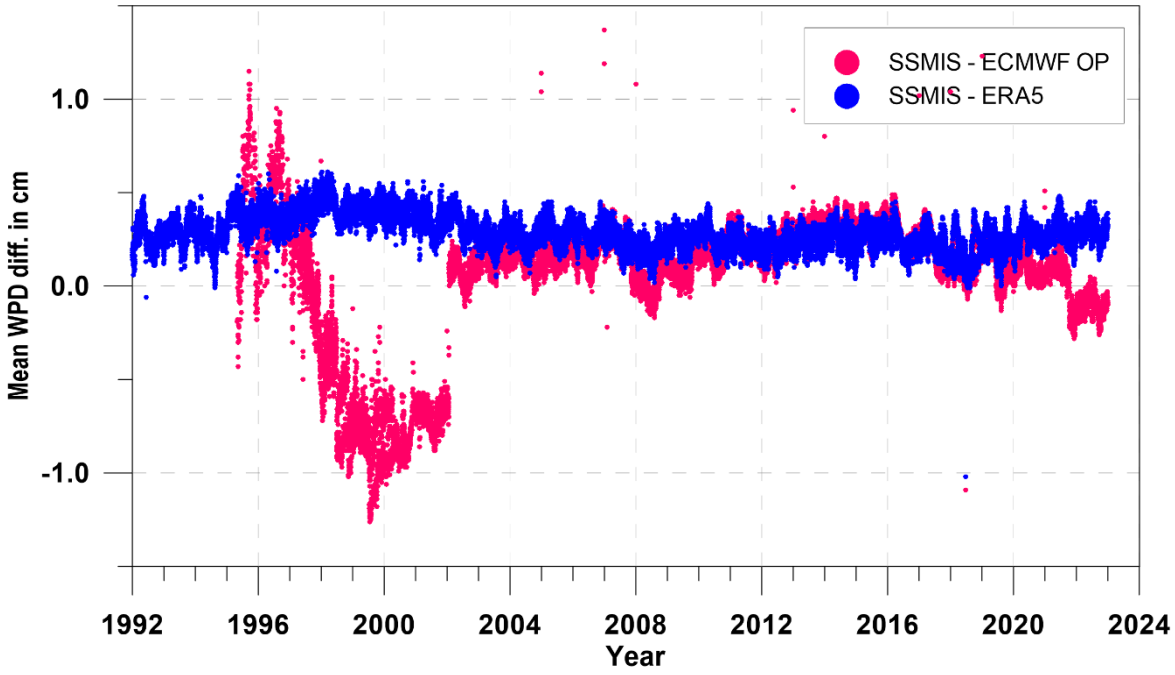


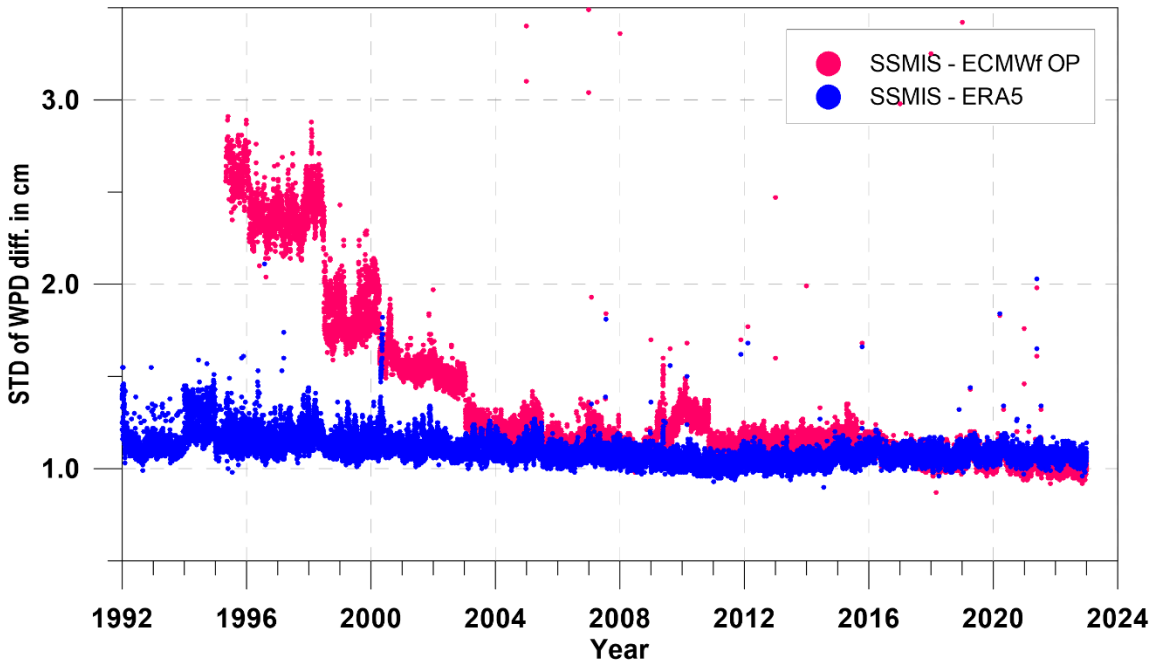


- **ERA Interim errors increased after 2011.**
- **ECMWF OP is not stable and it has very large errors before 2004.**

Comparison between ECMWF models and SSMIS (1992-2023)

Mean (left) and STD (right) of WPD differences between SSMIS and ECMWF OP (red) and between SSMIS and ERA5 (red) , in cm (ocean weighted values)

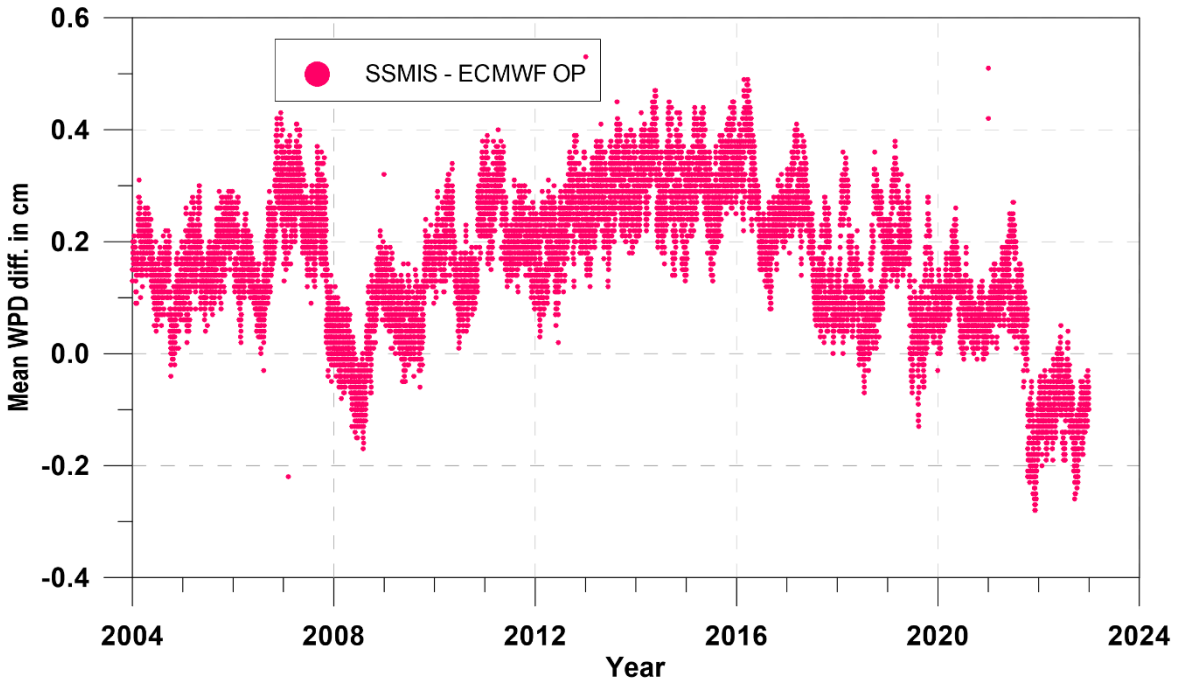




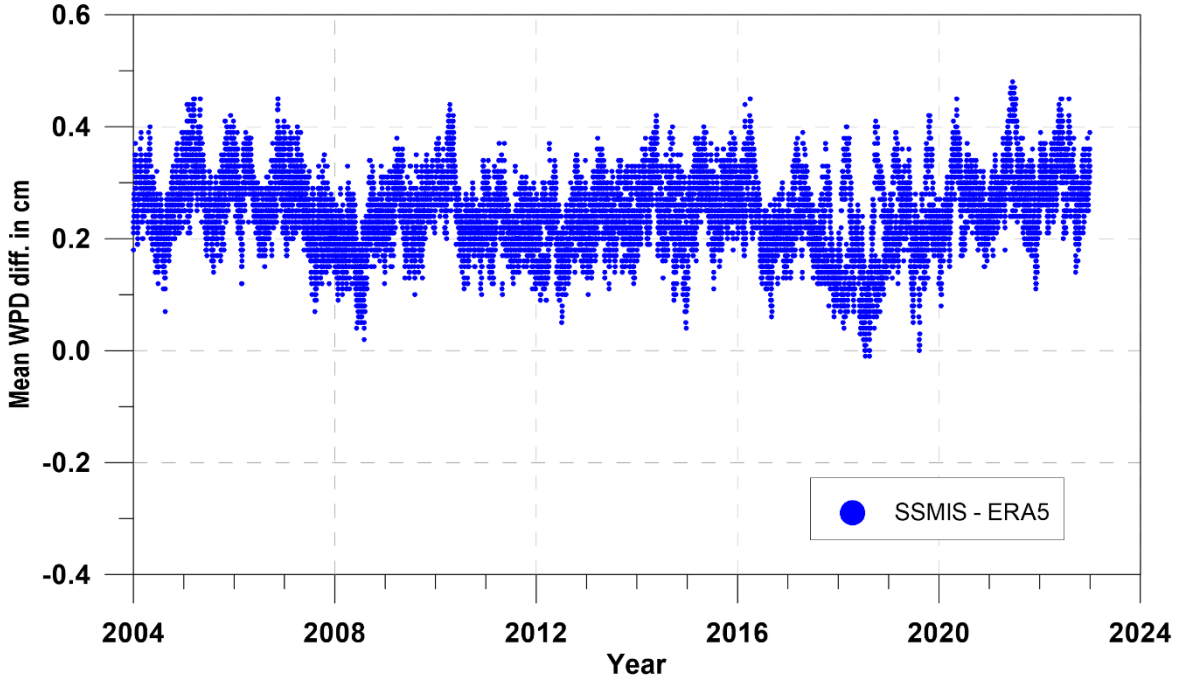
When compared with SSMIS, considered a stable WPD reference, ERA5 is significantly more stable than ECMWF OP and significantly better before 2017.

Comparison between ECMWF models and SSMI/SSMIS after 2004

Mean WPD differences between SSMIS and ECMWF OP in cm (ocean weighted values)



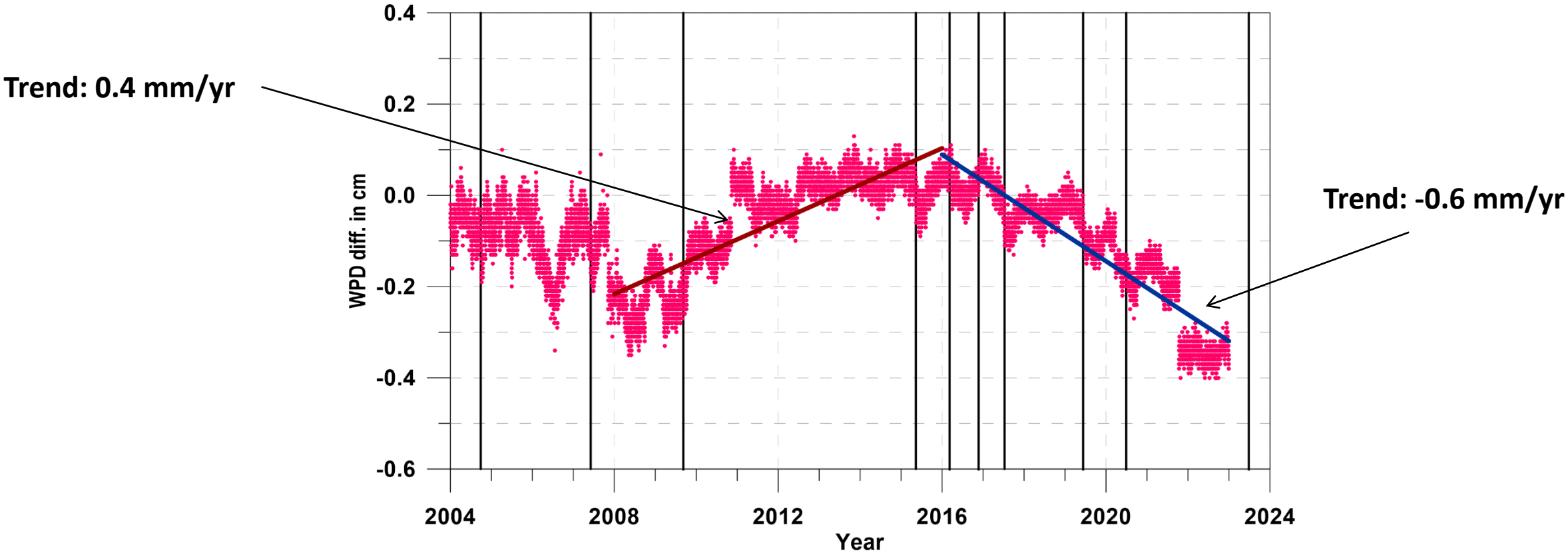
Mean WPD differences between SSMIS and ERA5, in cm (ocean weighted values)



After 2004, when compared with SSMIS, ERA5 is significantly more stable than ECMWF OP

Comparison between ERA5 and ECMWF OP after 2004

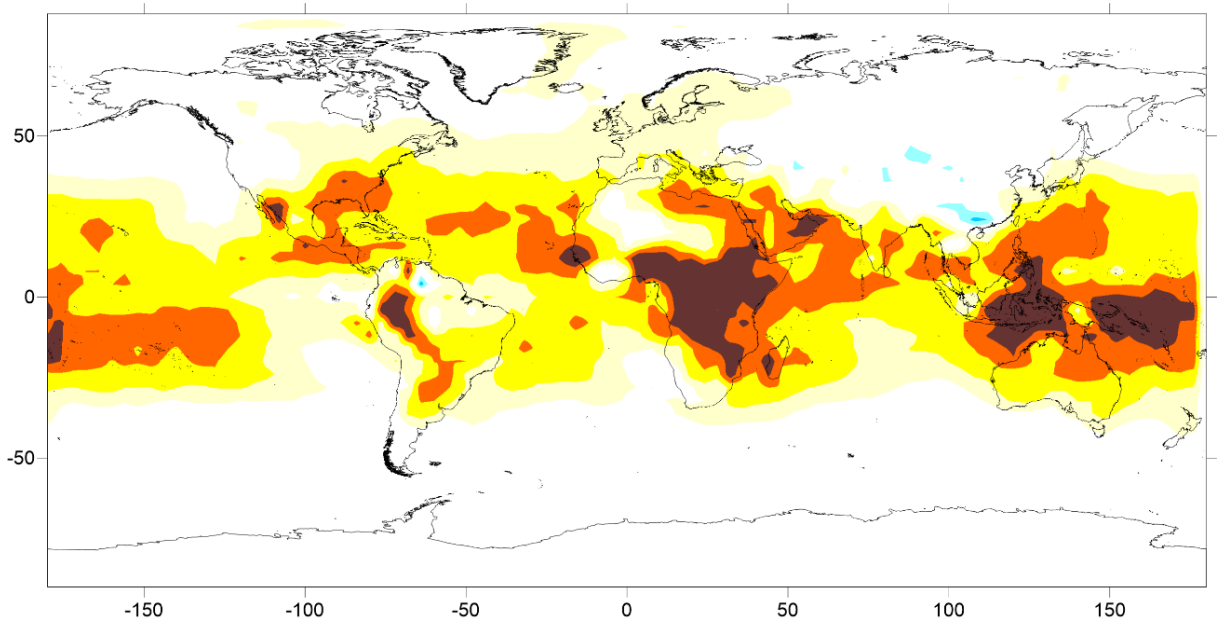
Mean WPD differences (ERA5 – ECMWF OP), in cm (global weighted values), after 2004.



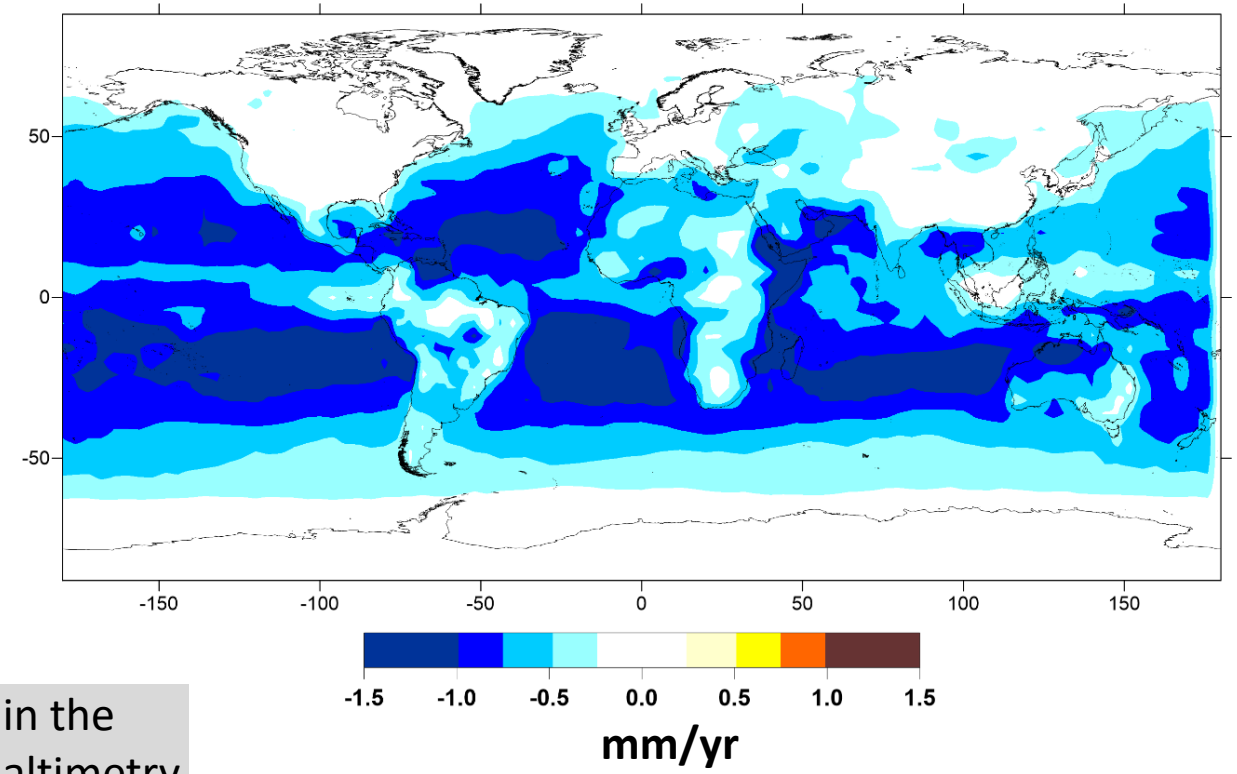
After 2004, ECMWF OP still has several discontinuities, which may induce significant trend errors.
Trend for period 2008.0-2016.0: 0.4 mm/yr; Trend for period 2016.0-2023.0: -0.6 mm/yr. These trends are larger than the target GCOS and IPCC trend error of 0.3 mm yr^{-1} over 10-year periods

Regional trends in WPD differences between ERA5 and ECMWF OP

2008.0-2016.0

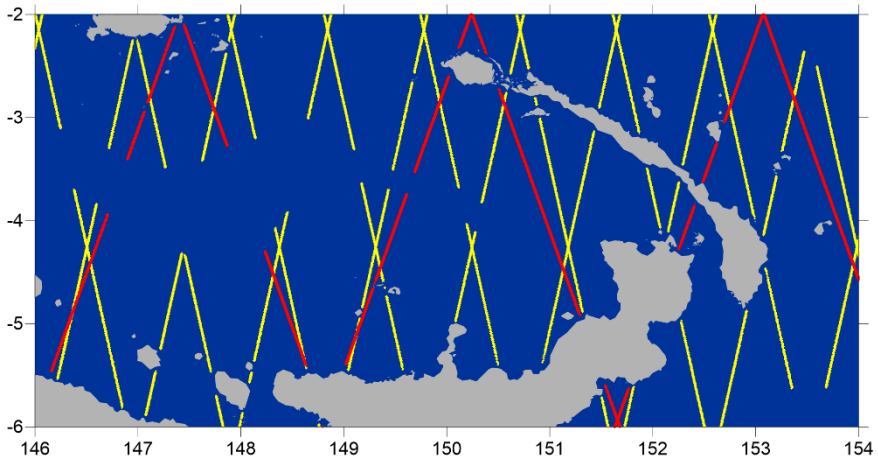


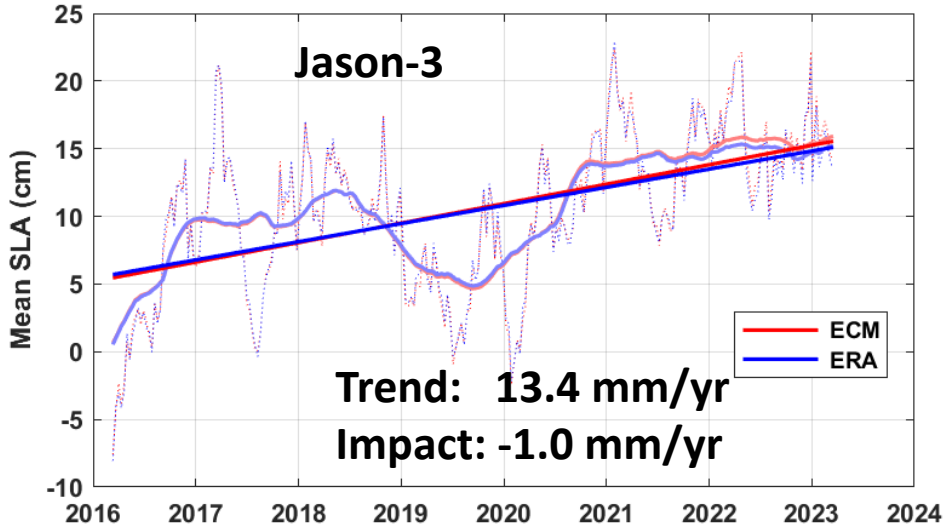
2016.0-2023.0

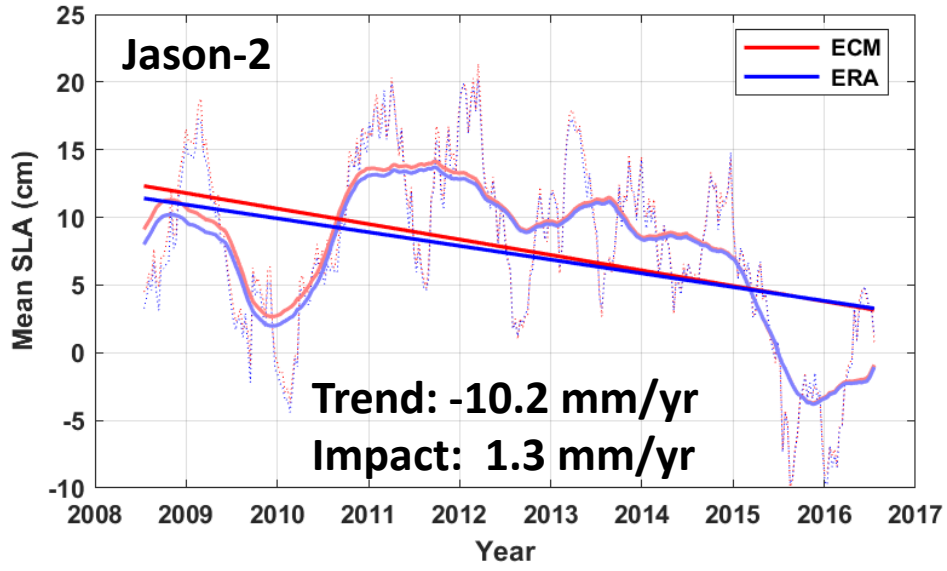


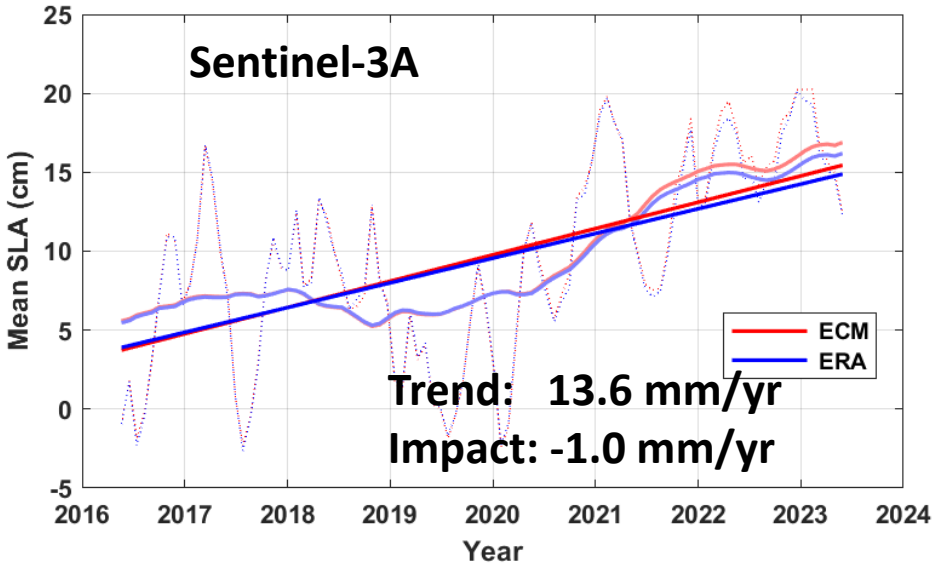
These WPD trends induce trends with the same magnitude in the SLA and in the sea level variation determined from satellite altimetry

Impact on SLA trends (Bismarck Sea)

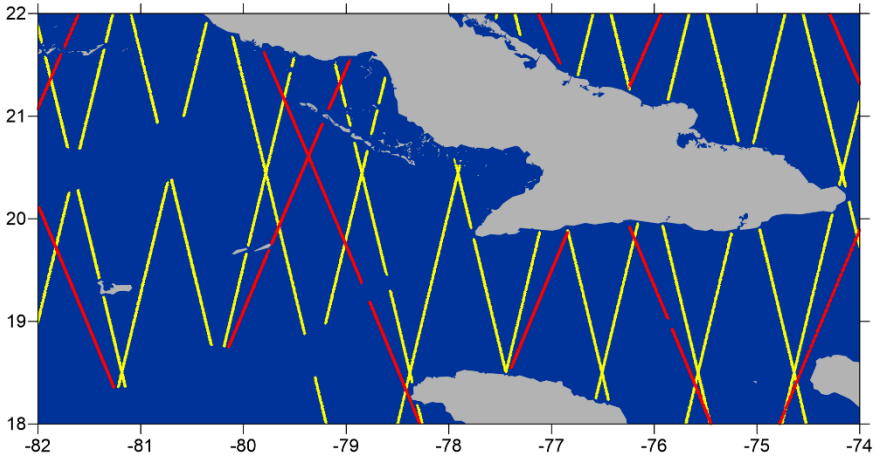


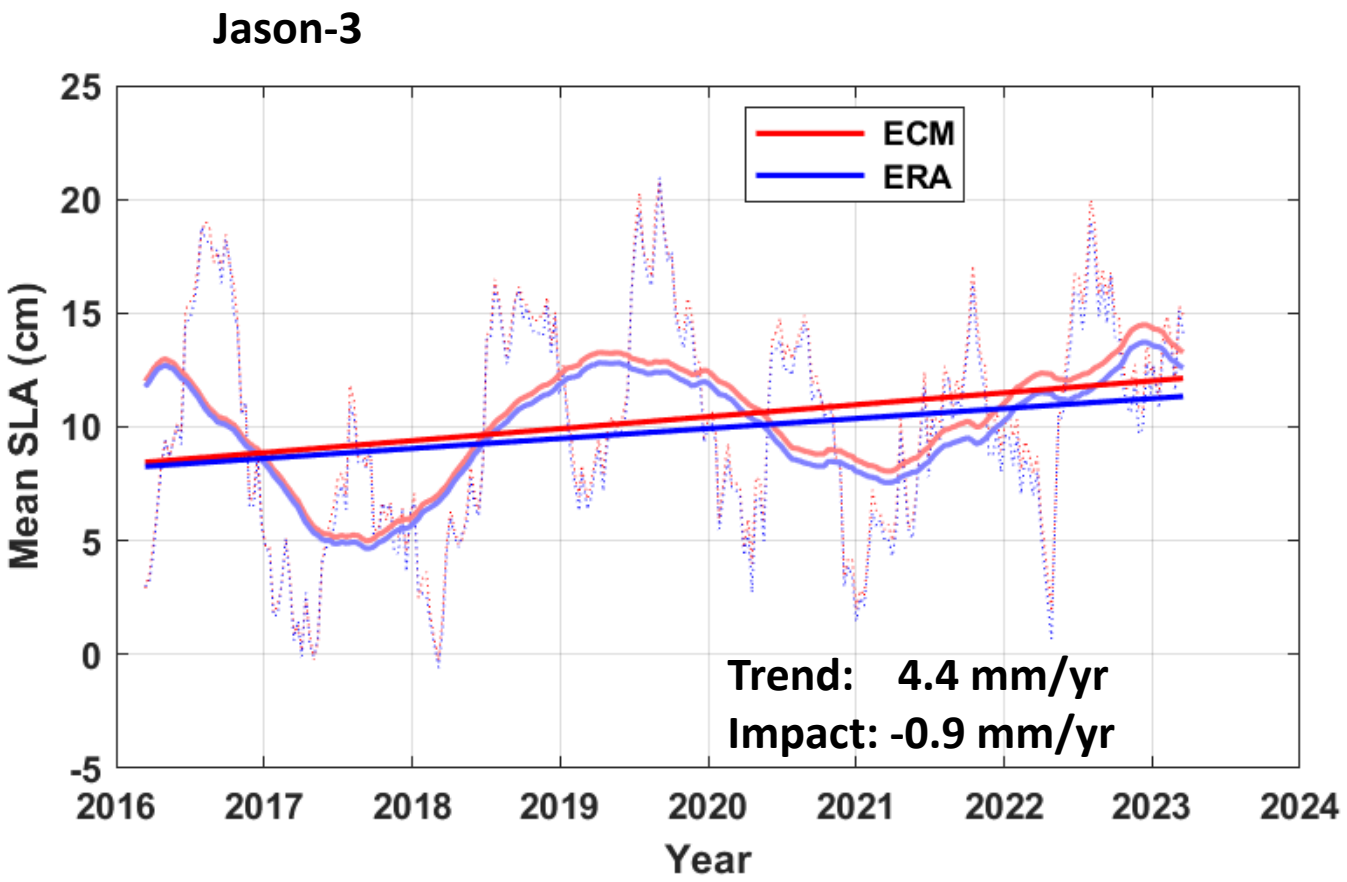




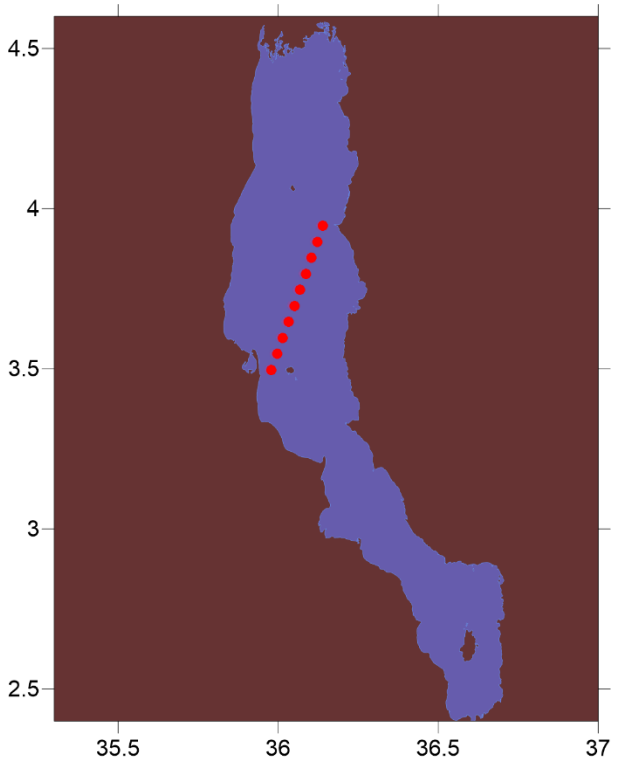


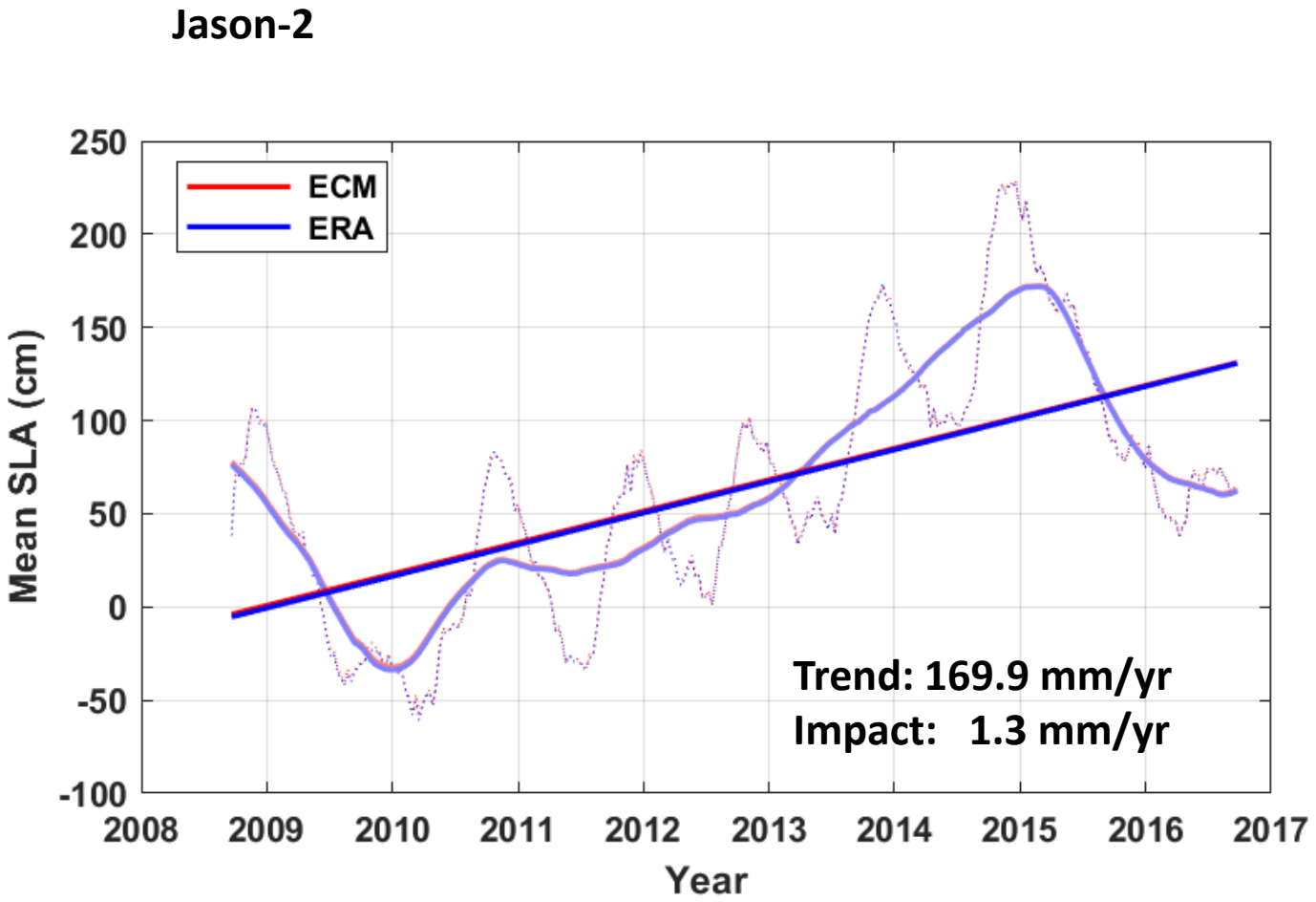
Impact on SLA trends (Cuba and Jamaica region)





Impact on SLA trends (Lake Turkana, Africa)





Conclusions

- **ECMWF OP model should not be used before 2004.**
- **After 2004, it has significant discontinuities, which in some regions introduce trend errors that can exceed 1 mm/yr, over periods of 7-8 years.**
- **Most relevant impacts are over the periods of the Jason-2 mission (phase A) and over the period of Jason-3 (phase A) and S3A missions.**
- **ERA5 is the best compromise between precision and stability and should be adopted for climate studies, whenever WPD based on observations are not available, such as coastal and inland water regions.**