OSTST 2026

Presentation

# Improving MWR-based retrievals of WTC in coastal areas

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IN PARTNERSHIP WITH

# Altimeters and microwave radiometers: a relationship that works

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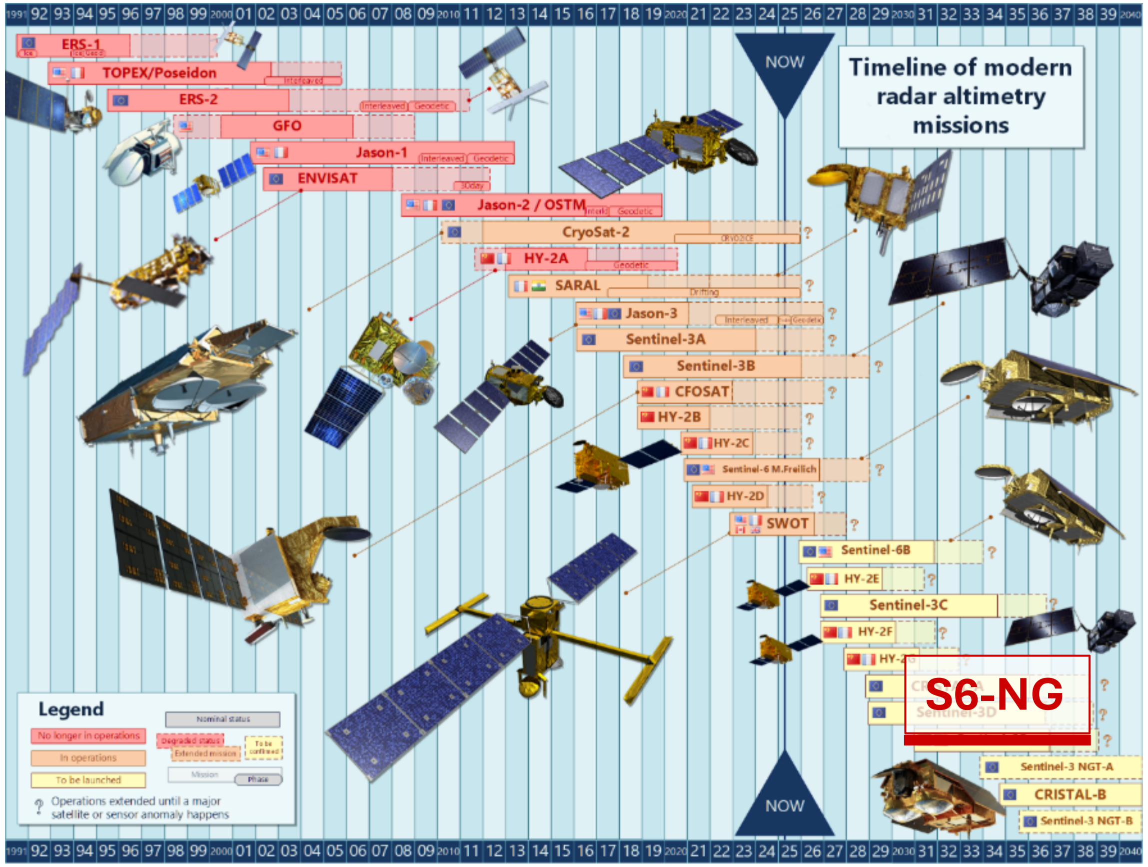
- Sea level is globally measured by satellite altimeters
- Need to correct altimeter ranges for atmospheric path delays
- *Water vapour* is dominant source of uncertainty in altimetry
- *Wet tropospheric correction (WTC)* is essential to meet SSH accuracy requirements
- MW radiometers flown jointly with altimeters for 30+ years (and counting)

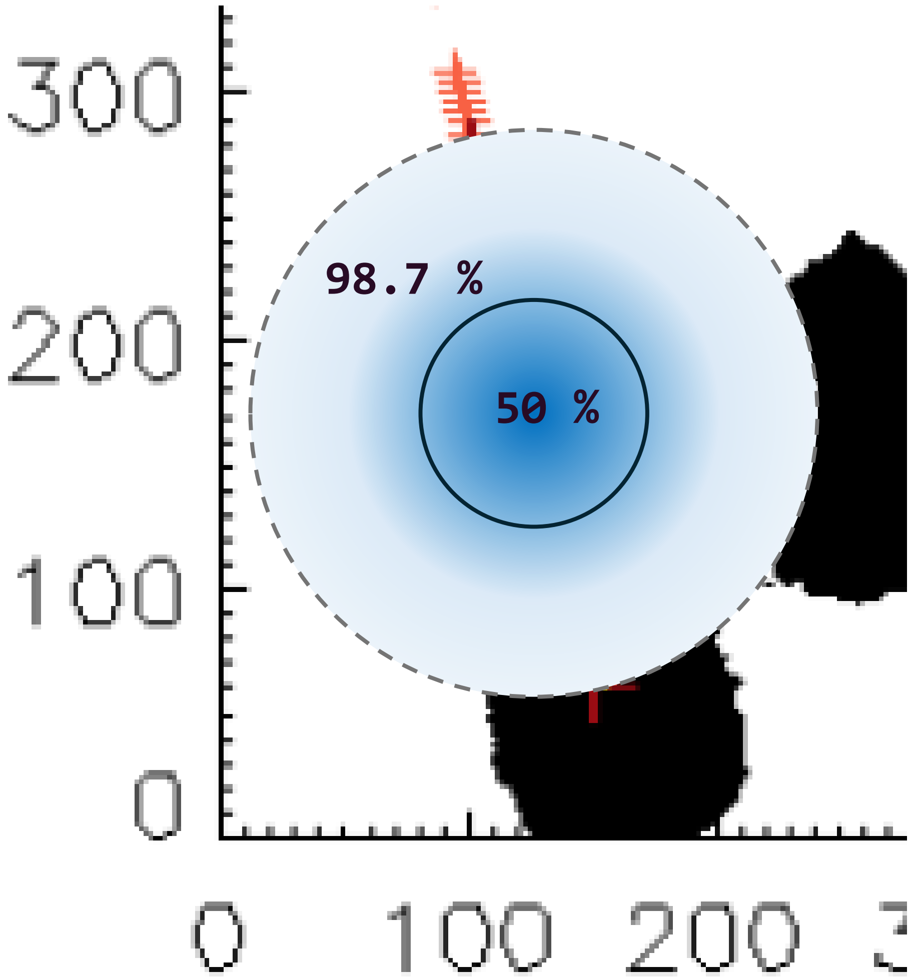



*Aviso+ (2022). Timeline of modern radar altimetry missions.*
*https://doi.org/10.24400/527896/A02-2022.001 version 2025/06*

# Characteristics of microwave radiometers



- FDR4ALT: generate FDRs and TDPs from ERS-1/2, Envisat (1991-2012)
- Two-channel MWRs:
  - 23.8 GHz: water vapour
  - 36.5 GHz: liquid water
- 7 Hz observation frequency, ➔ ~1 km footprint centre spacing
- Various retrieval schemes (e.g., those presented in this session)
- Near-nadir observations
- Footprint: 2D-Gaussian, ~20 km FWHP




ENV, 36/979
2005-05-02

# The need for coastal correction

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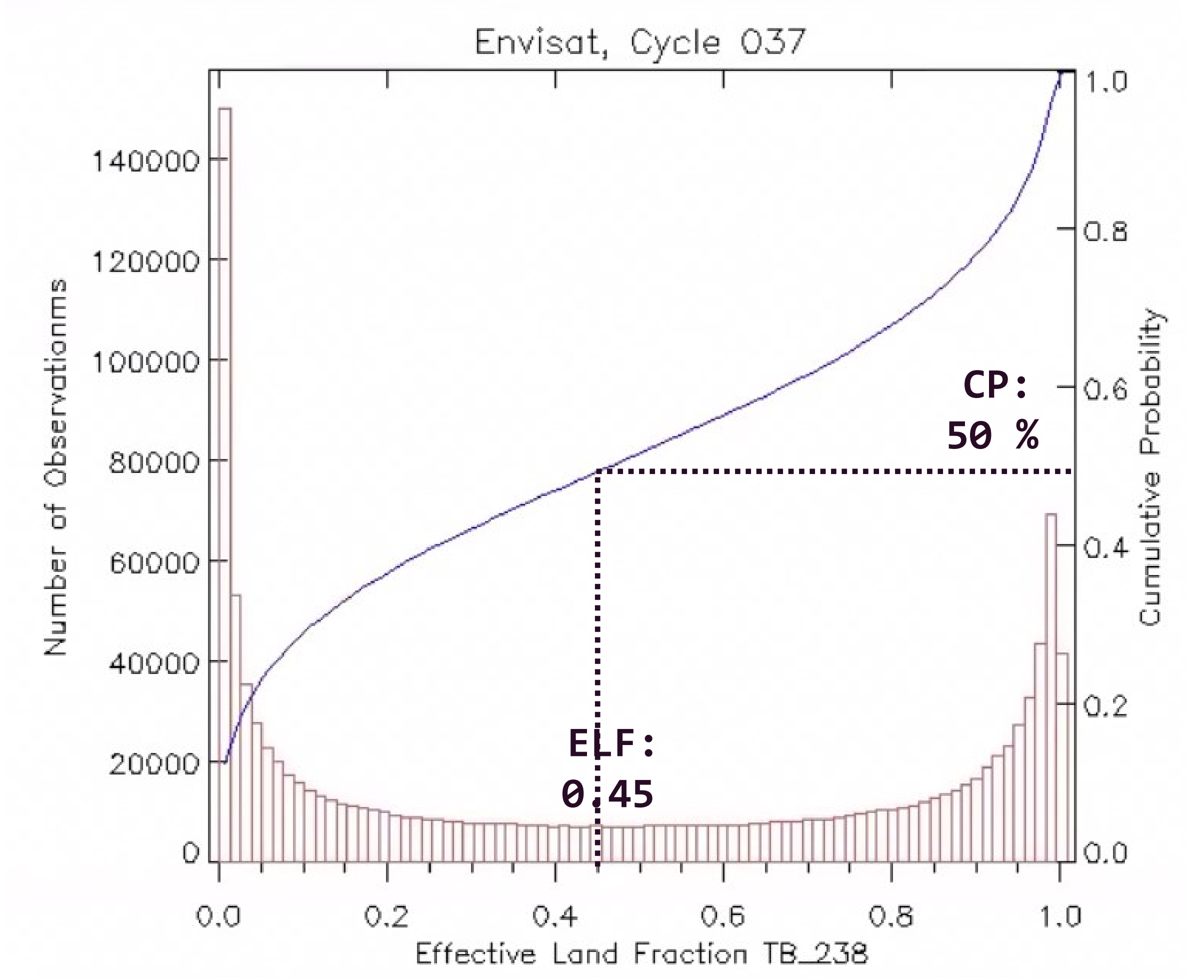
- Land surface ~100 K warmer than ocean surface
- Ca. 1 K TB increase per 1 % ELF ➔ systematic overestimation in WTC, TCWV in coastal areas
- Globally, ca. 6 % mixed MWR footprints at FWHP = 20 km
- Distribution slightly skewed towards low ELFs
- Correcting up to ELF = 0.45 saves half the coastal observations



# Retrieval model for mixed footprints



$$TB_O = \underbrace{(1.0 - \boldsymbol{ELF}) \times \boldsymbol{TB_W}}_{\text{above-water}} + \underbrace{\boldsymbol{ELF} \times \boldsymbol{TB_L}}_{\text{above-land}}$$

$$\boldsymbol{TB_W} = \frac{TB_O - \boldsymbol{ELF} \times \boldsymbol{TB_L}}{1.0 - \boldsymbol{ELF}} \; ; \; \Delta\boldsymbol{TB_W} = \ldots$$

$\boldsymbol{ELF}$ : effective land fraction

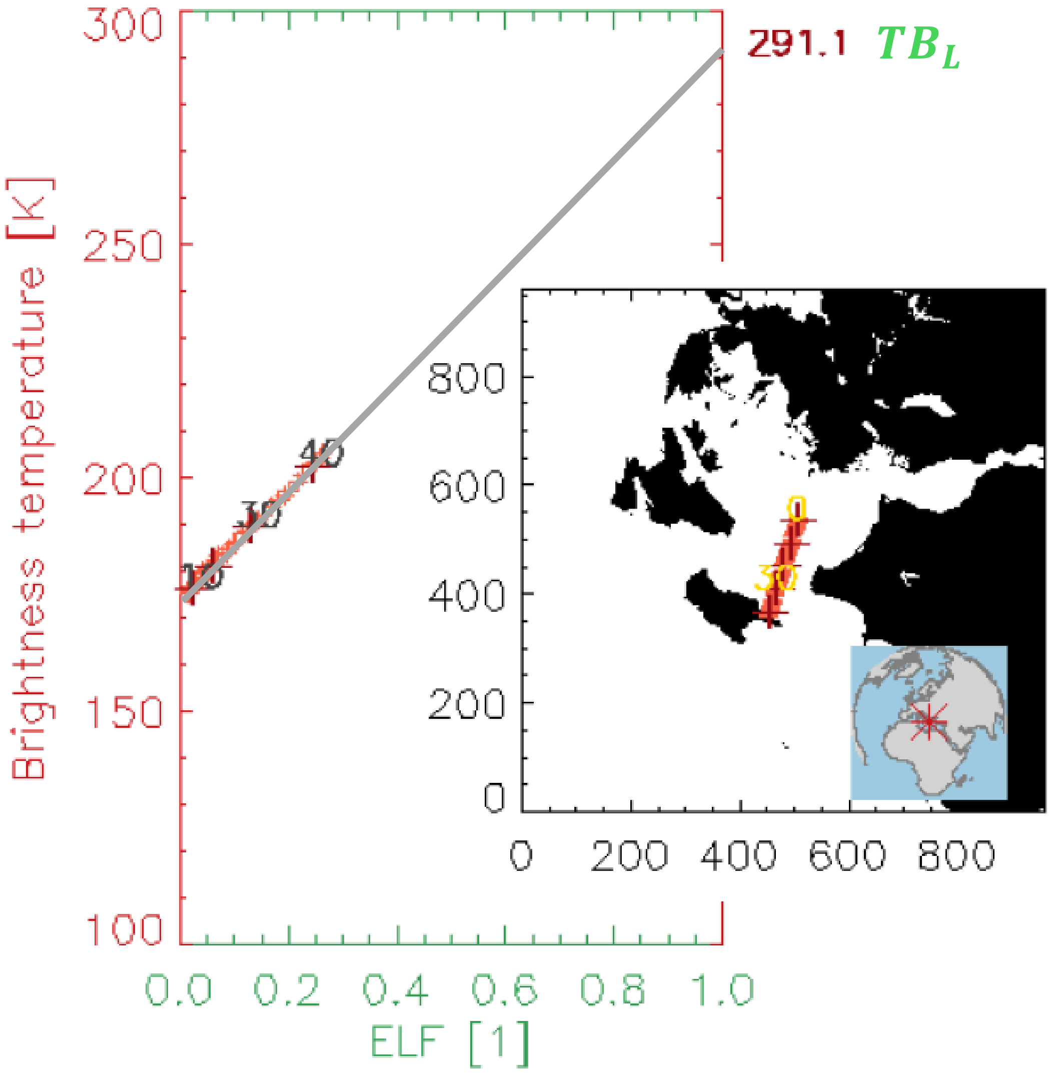
$\boldsymbol{TB_L}$ : corresponding effective TB above land

*"Effective"*: Convolution with footprint sensitivity

# Correction approach



- Based on *[Bennartz, 1999]*, with data-driven estimation of $TB_L$
- Use ~250 m land/sea mask *[Mikelsons et al., 2021]* *to calculate* $ELF$
- Extrapolate $TB_O$ within a moving window *to estimate corresponding* $TB_L$
- Use $ELF$, $TB_L$, and $TB_O$ to derive $TB_W$, $\sigma TB_W$ at the target position
- Use LC-corrected $TB_W$, $\sigma TB_W$ as input for TCWV/WTC retrieval



# Accurate geolocation matters!

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Along-track correction

Across-track correction

FWHP characterization

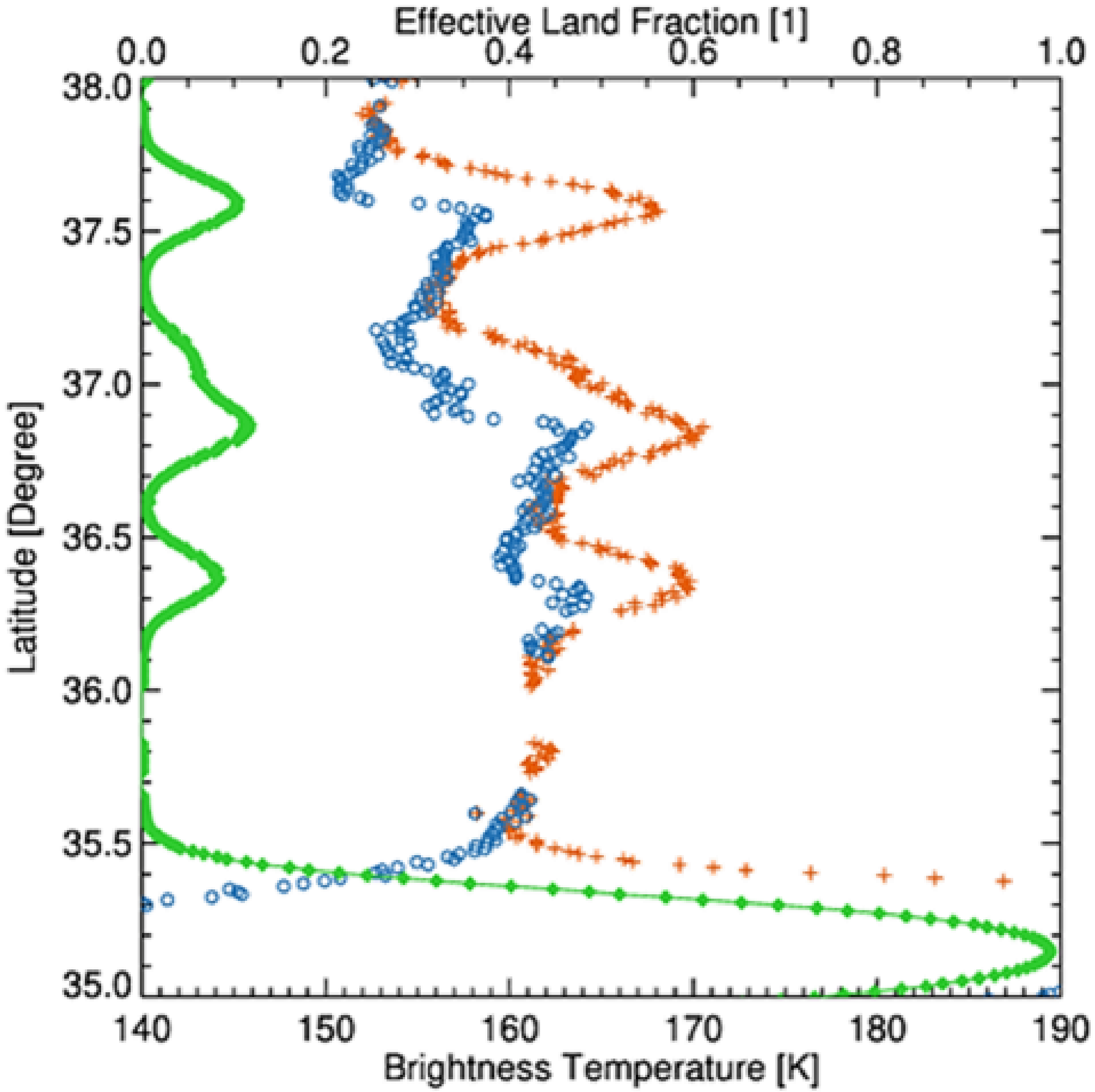
**Table 2. ELON, ECRO and FWHP estimates (mean ± 1 σ). N indicates the total number of retrievals used per aggregation. The geolocation error represents the length of the vector generated from combining the orthogonal ELON and ECRO contributions.**

| Satellite | Channel [GHz] | ELON [km] | ECRO [km] | Geolocation error [km] | FWHP [km] |
|---|---|---|---|---|---|
| ERS-1 | 23.8 | +2.38±0.07 N=2,669 | -0.32±0.08 N=2,578 | 2.40±0.07 | 20.80±0.04 N=2,417 |
| ERS-1 | 36.5 | +1.46±0.05 N=2,690 | -0.17±0.07 N=2,607 | 1.47±0.05 | 21.40±0.04 N=2,579 |
| ERS-2 | 23.8 | +1.60±0.05 N=2,583 | +1.12±0.08 N=2,518 | 1.95±0.06 | 20.48±0.03 N=2,144 |
| ERS-2 | 36.5 | +1.38±0.10 N=2,716 | +1.08±0.12 N=2,643 | 1.75±0.11 | 21.78±0.04 N=2,548 |
| Envisat | 23.8 | +0.30±0.06 N=3,727 | -1.00±0.08 N=3,578 | 1.04±0.08 | 20.72±0.04 N=3,558 |
| Envisat | 36.5 | -0.06±0.08 N=3,423 | -1.10±0.06 N=3,404 | 1.10±0.06 | 18.59±0.04 N=2,975 |

*Source: Fell et al., 2026 (under discussion at AMT, [10.5194/egusphere-2026-994](10.5194/egusphere-2026-994))*

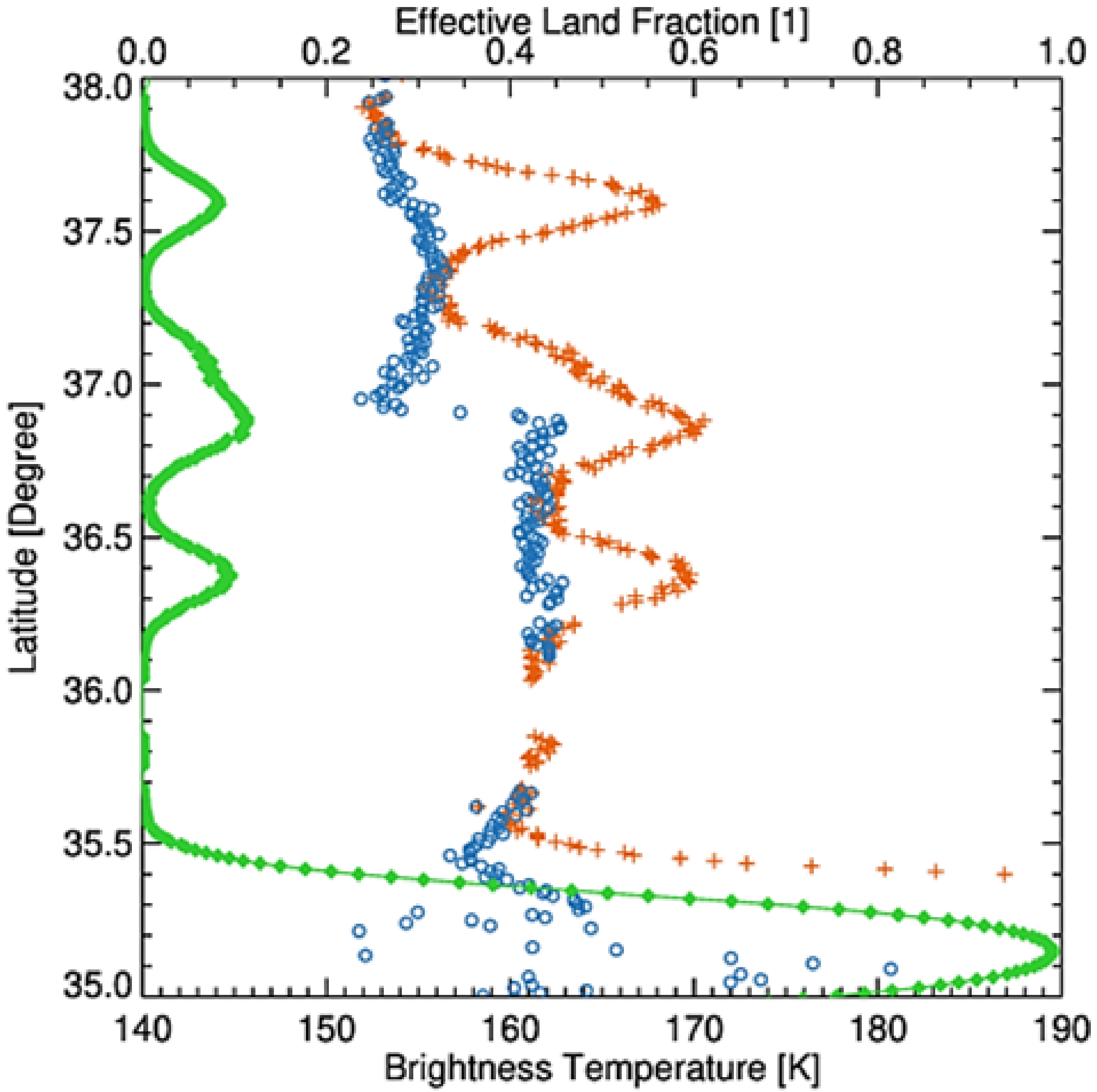
ERS-1, TB_238
Aegean Islands

TBW retrieval, geolocation uncorrected



ERS-1, TB_238
Aegean Islands

TBW retrieval, geolocation corrected



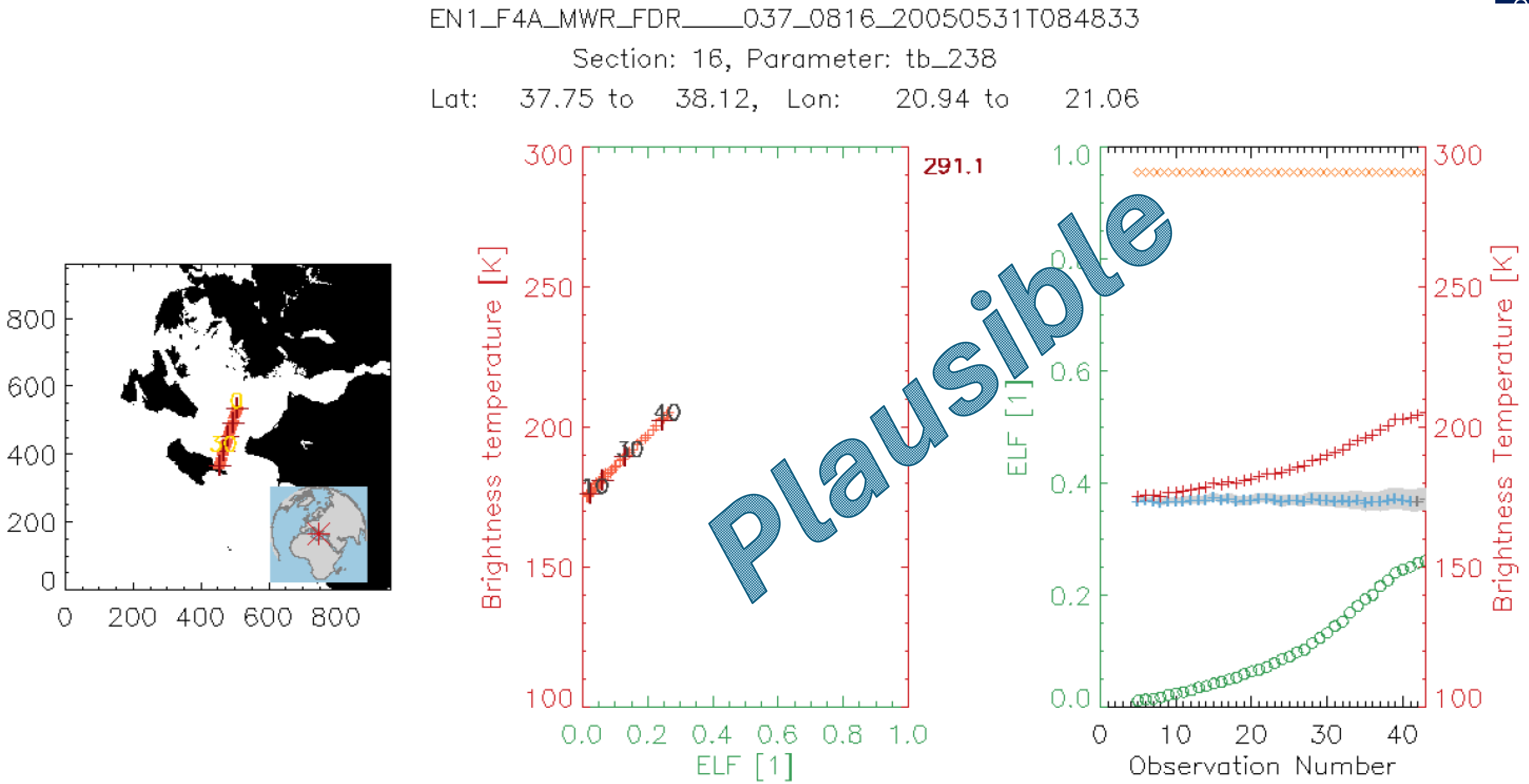
# Implementation approach



- Implementation aspects
  - Identify sea-ice affected observations (after Tran et al., 2009)
  - Apply multi-parameter regression accounting for atmospheric and surface TB gradients
  - Provide individual retrievals for each observation ➔ preserve local structures
  - Avoid use of external products (except land-sea mask) ➔ NRT-ready, no artefacts
- Operational applicability requires robustness!
  - Apply geolocation correction to reconcile TB observations and ELF
  - Split orbit into homogeneous segments based on ELF extrema
  - Ensure robustness of regression
- Diagnostic tools facilitate comprehension of unexpected behaviour

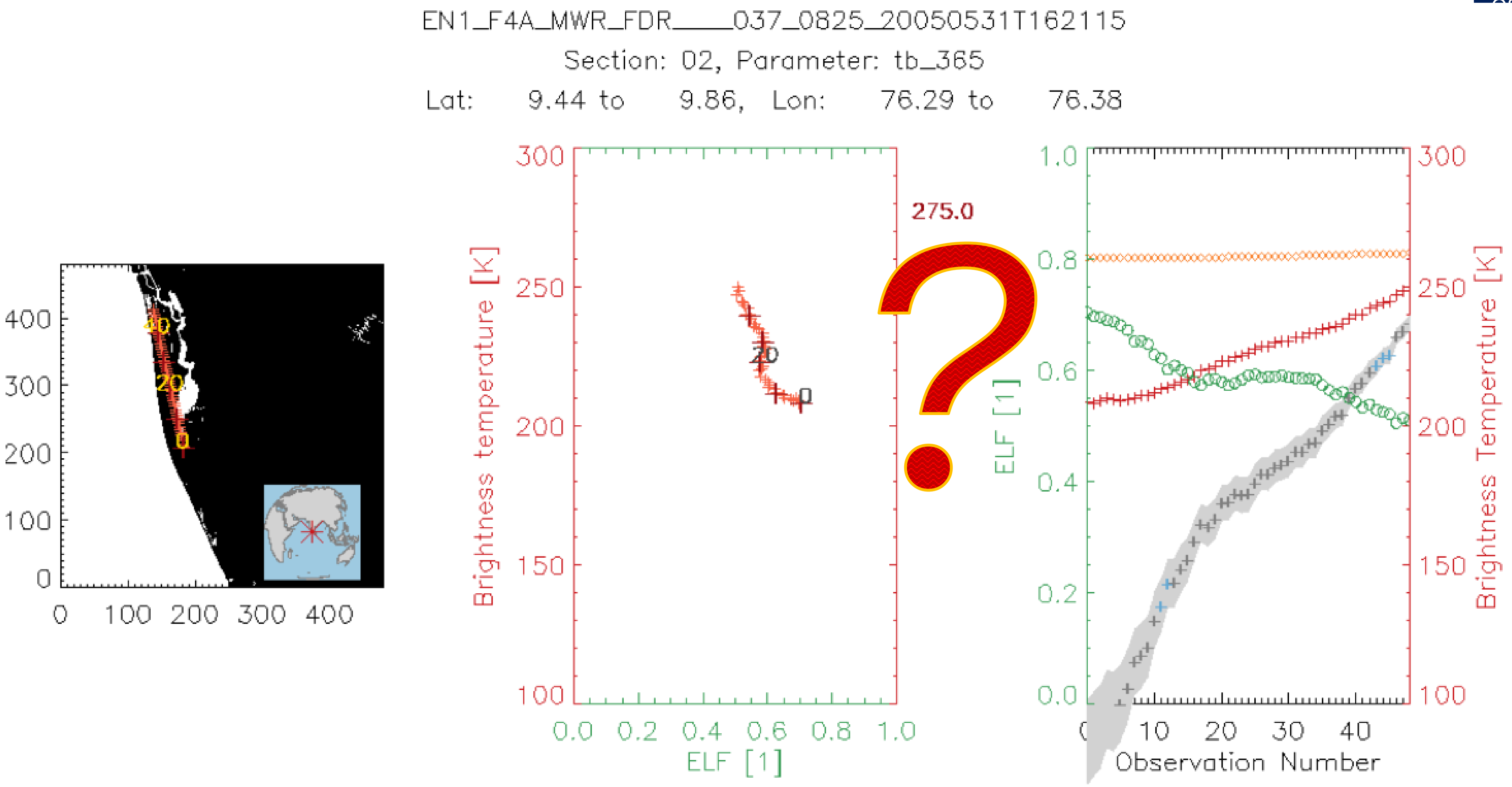
# Coastal correction: when in works…





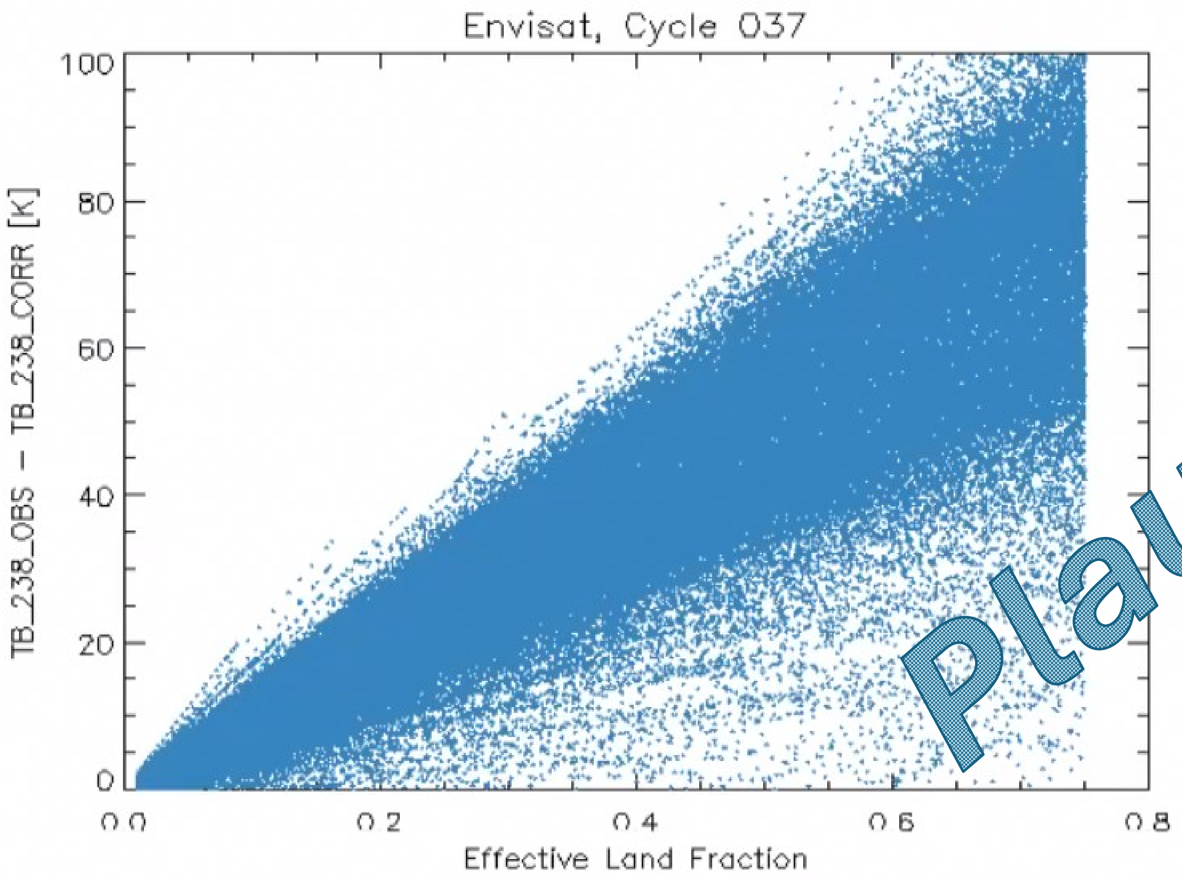
# Coastal correction: … and when is doesn't





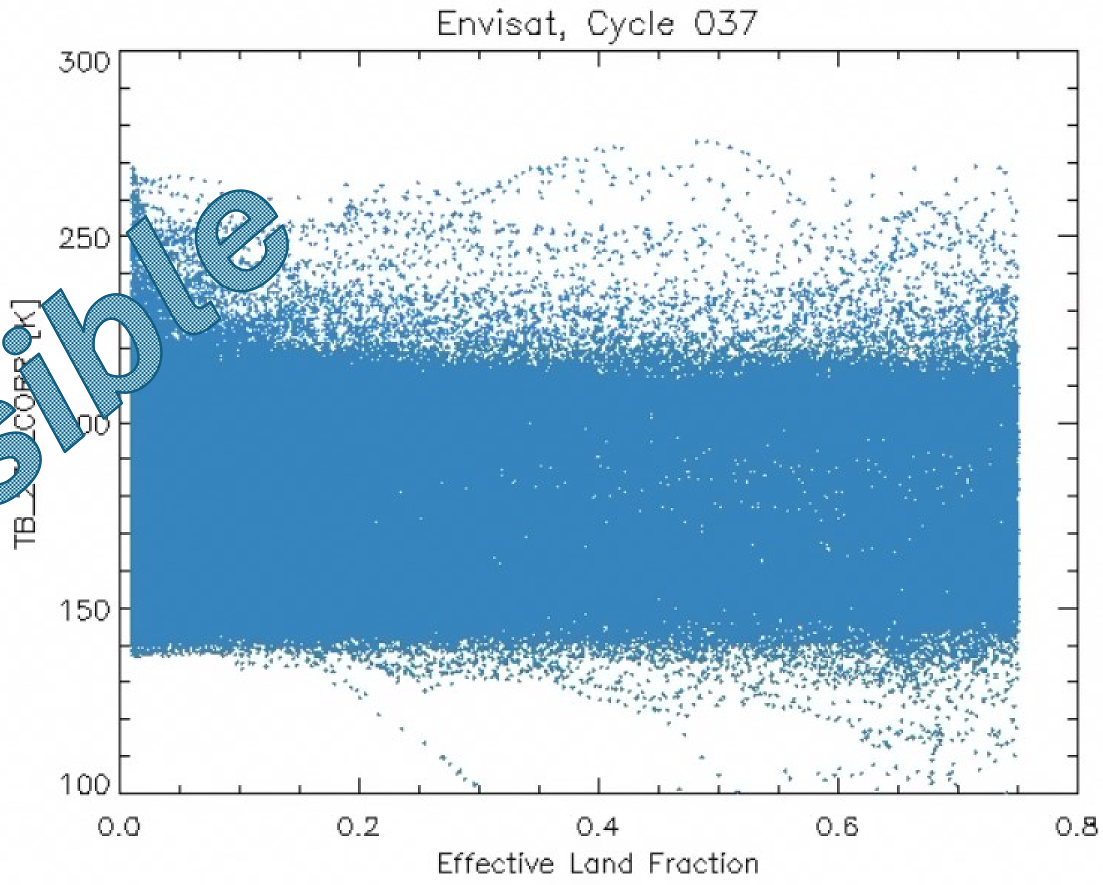
# 233,197 retrieved coastal corrections for Envisat cycle 037






TBO_238, correction to be applied

Plausible




TBW_238, corrected values

**Retrieval rate 0.01 < ELF < 0.75: 36.3 %**

# First validation attempts

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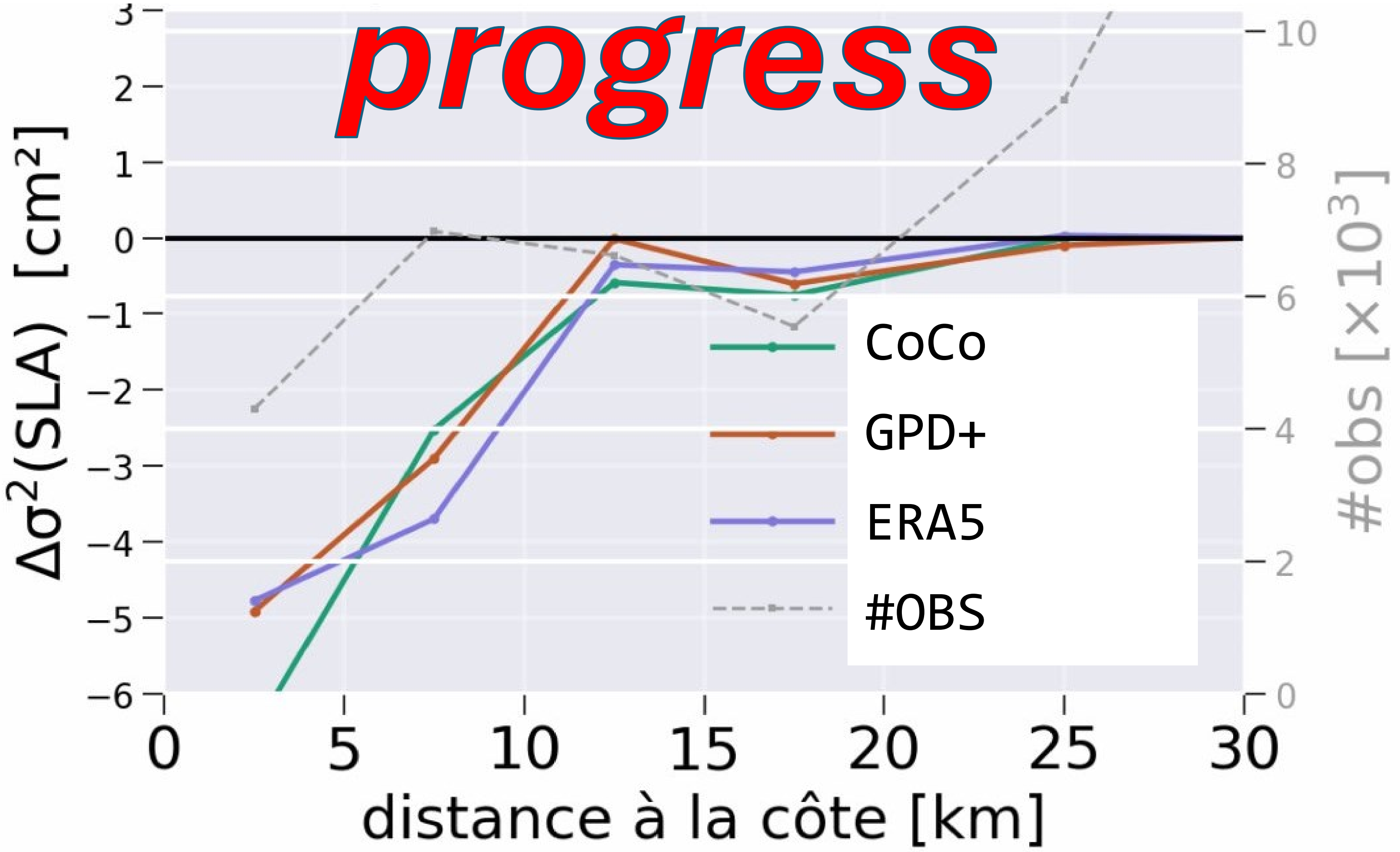
work in progress



# Summary



- MWR-based TCWV/WTC retrievals can be brought closer to the coast
  - Data-driven, no dependence on external information, except static land-sea mask
  - Preserves local structures, supports NRT, avoids multi-product incompatibilities
- For the presented method to work …
  - … the geolocation of the effective footprint centre must be accurately known
  - … segmentation into homogeneous subsections is essential
  - … the applied land mask must represent the conditions during the overpass
- Initial results plausible, evaluation ongoing
- Coastal correction currently applied to full ERS-1/2 + ENV TB time series
- Method can be transferred to similar instruments (S3-MWR, S6-AMR/C, …)