ESA-JAXA Pre-Launch EarthCARE Science and Validation Workshop

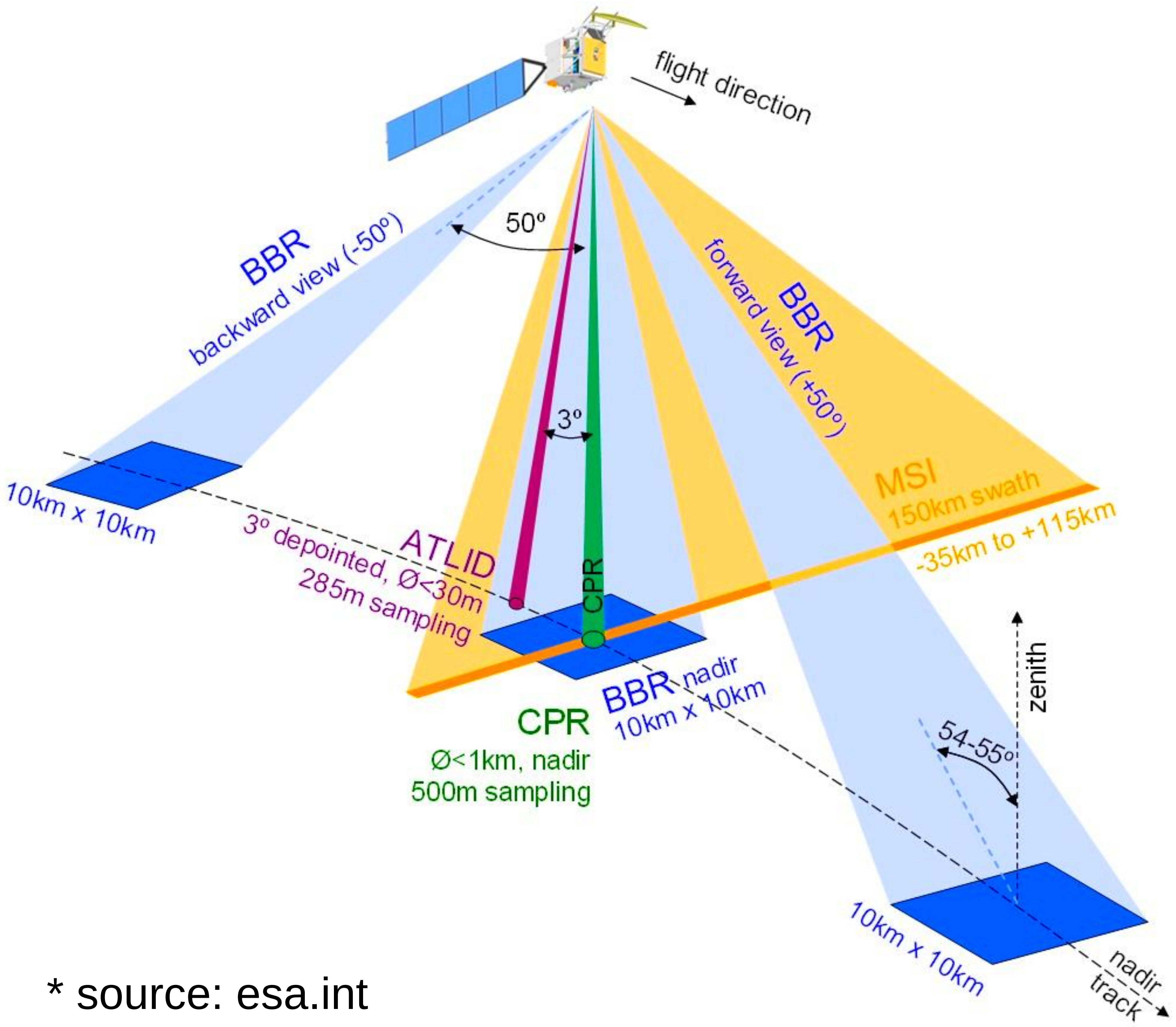
13 – 17 November 2023 | ESA-ESRIN, Frascati (Rome), Italy

Geolocation and co-registration of the EarthCARE CPR and ATLID instruments

Bernat Puigdomènech Treserras and Pavlos Kollias
McGill University

Introduction

Instrument geolocation plays a critical role in achieving the objectives of the EarthCARE mission



* source: esa.int

Introduction

The **Attitude Determination System** (ADS) is designed to deliver precise satellite **geolocation** and pointing information. However, errors or factors like thermoelastic distortions can lead to miscalibration errors.

Actual measurements can help validate and assess the geolocation of each instrument. **Co-registration** is especially important, as the measurements are combined in the **synergistic algorithms**.

A detailed analysis will be conducted on data collected over Natural Targets, such as **coastlines** and **areas with significant elevation gradients**, to asses and validate the geolocation of each instrument.

Objectives

The **absolute geolocation error** for the EarthCARE L1b products should be **less than 500m** and **350m (goal 200m) for the co-registration**

Data Acquisition

Establish a reliable representation of the Earth's surface / test with actual measurements

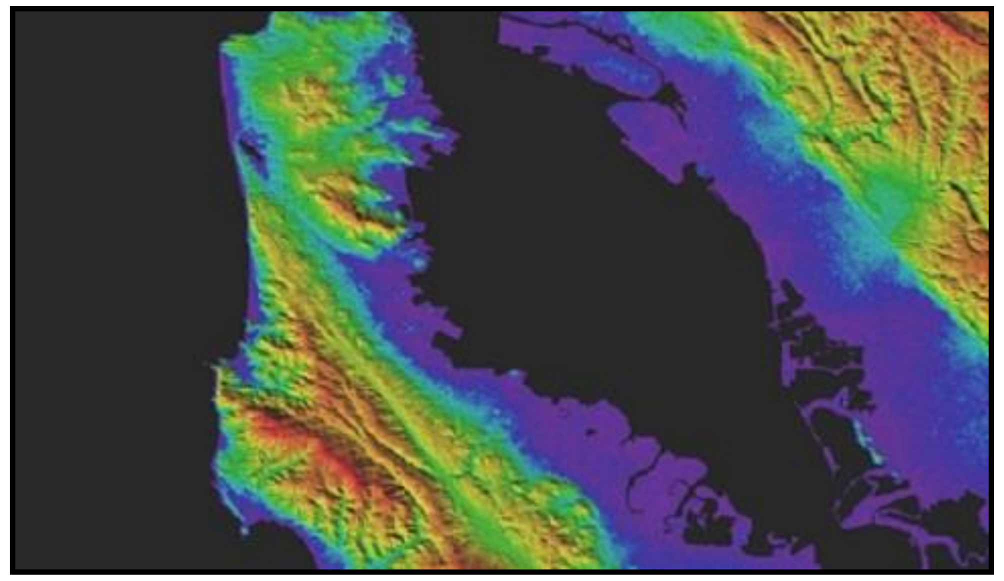
Digital Elevation Model

ASTER
Advanced **S**paceborne **T**hermal **E**mission and **R**eflection Radiometer (NASA’s Terra satellite)

Copernicus

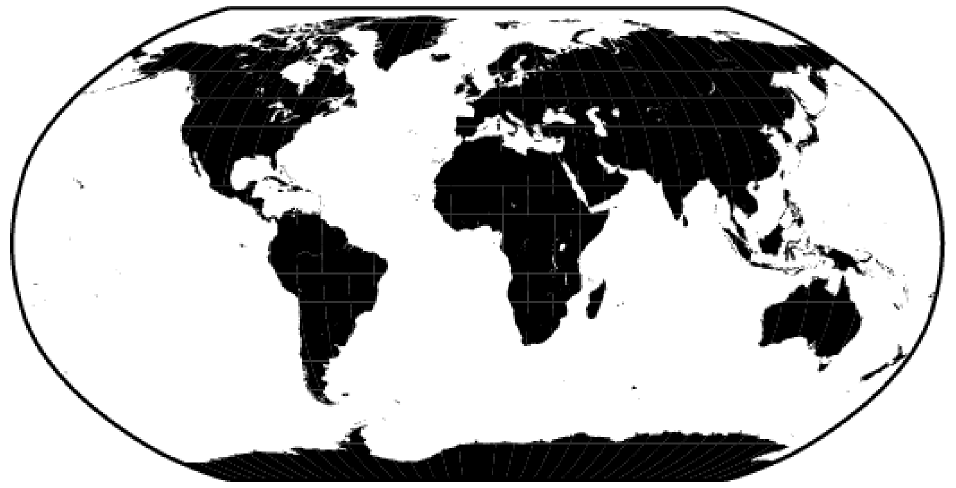
EU Space Programme (TanDEM-X satellite)

1-arc seconds resolution (~30m)

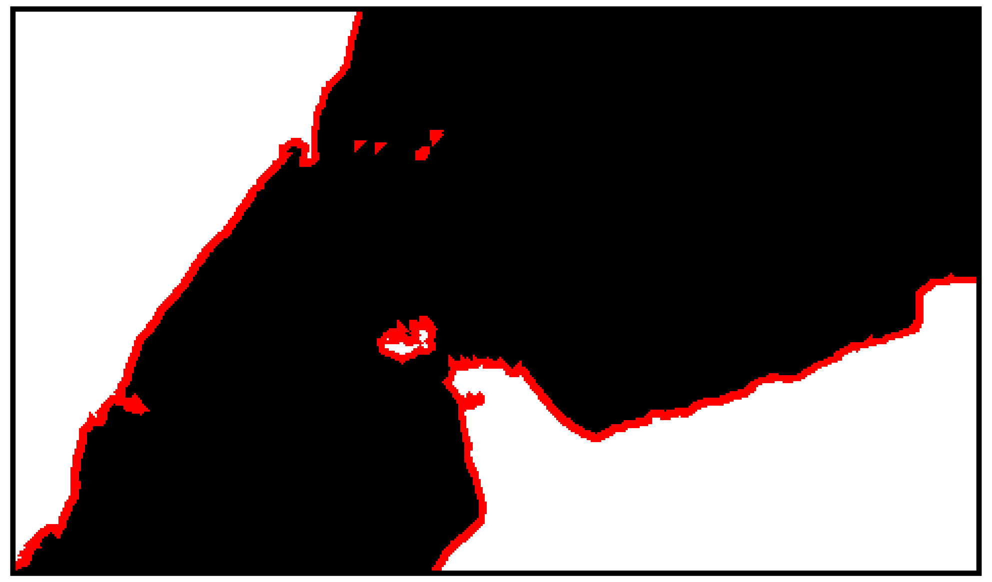


Coastlines

GSHHG
A **G**lobal **S**elf-consistent, **H**ierarchical, **H**igh-resolution **G**eography Database

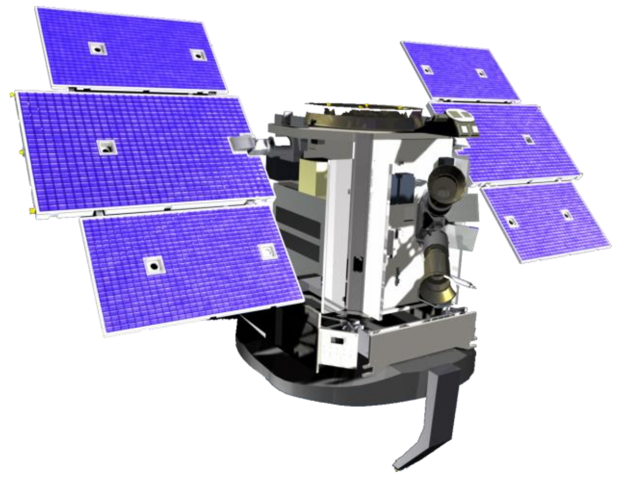


ASTER and **Copernicus**
Water **B**ody **M**asks (ocean, rivers and lakes)

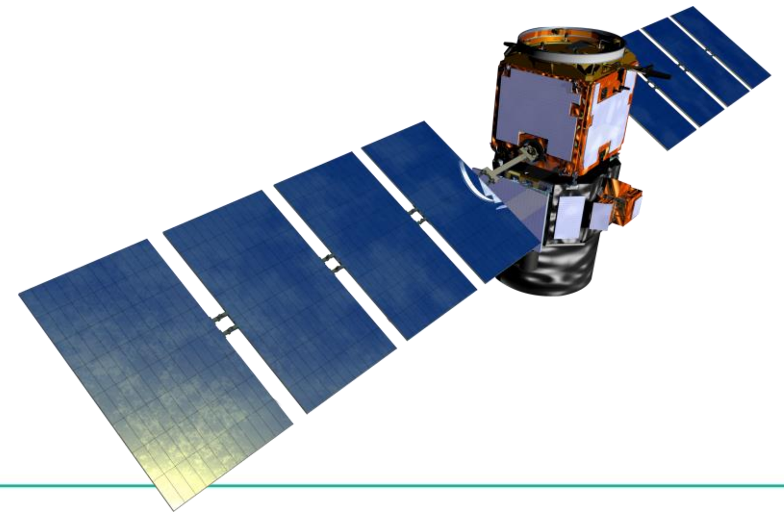


Measurements

CloudSat
2B-GEOPROF
(2006-2019)
Good quality profiles / no clouds



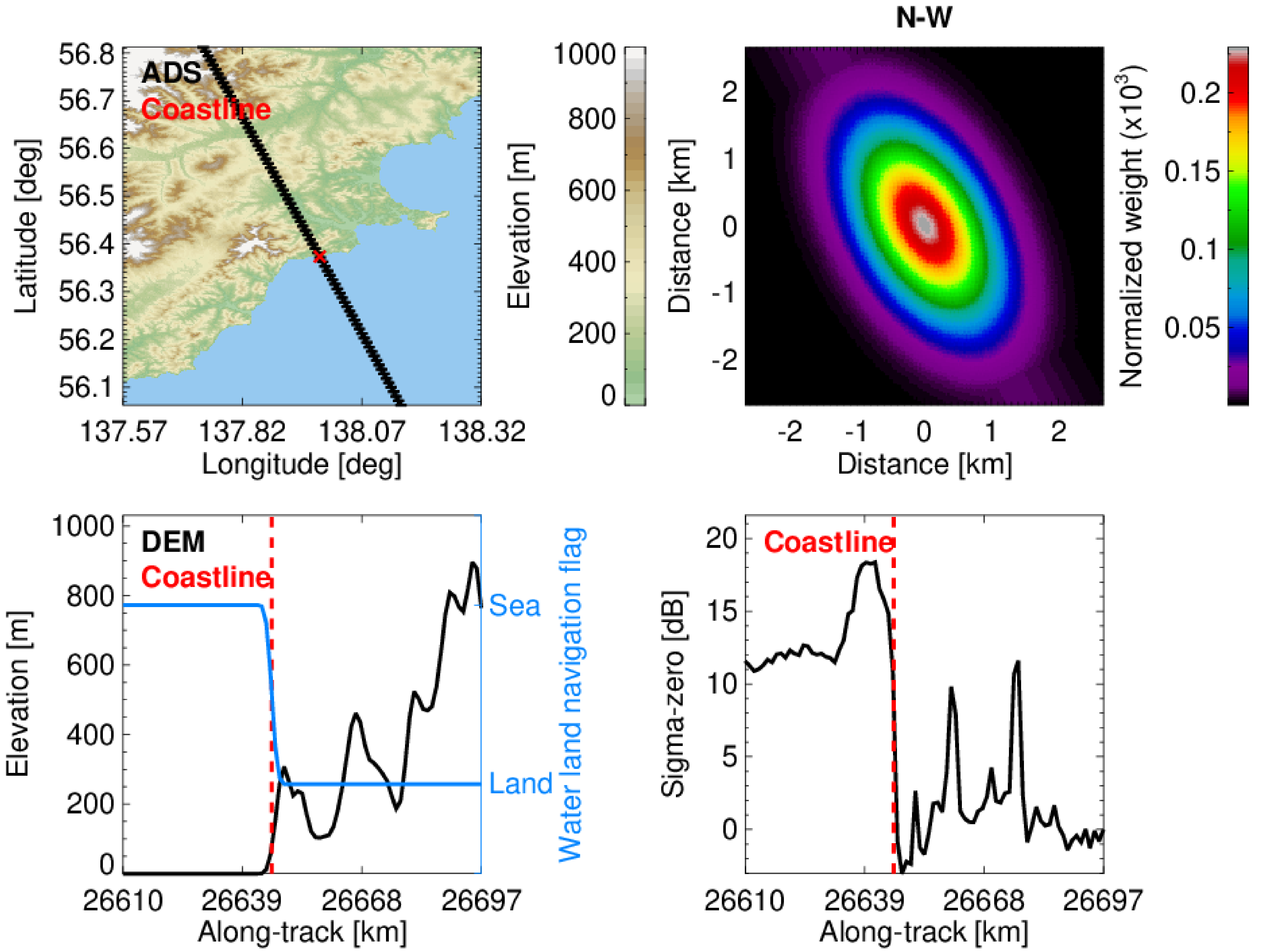
CALIPSO
LID_L2_333mMLay-Standard-V4-51
(2006-2019)
Good quality profiles / surface detection



Tools

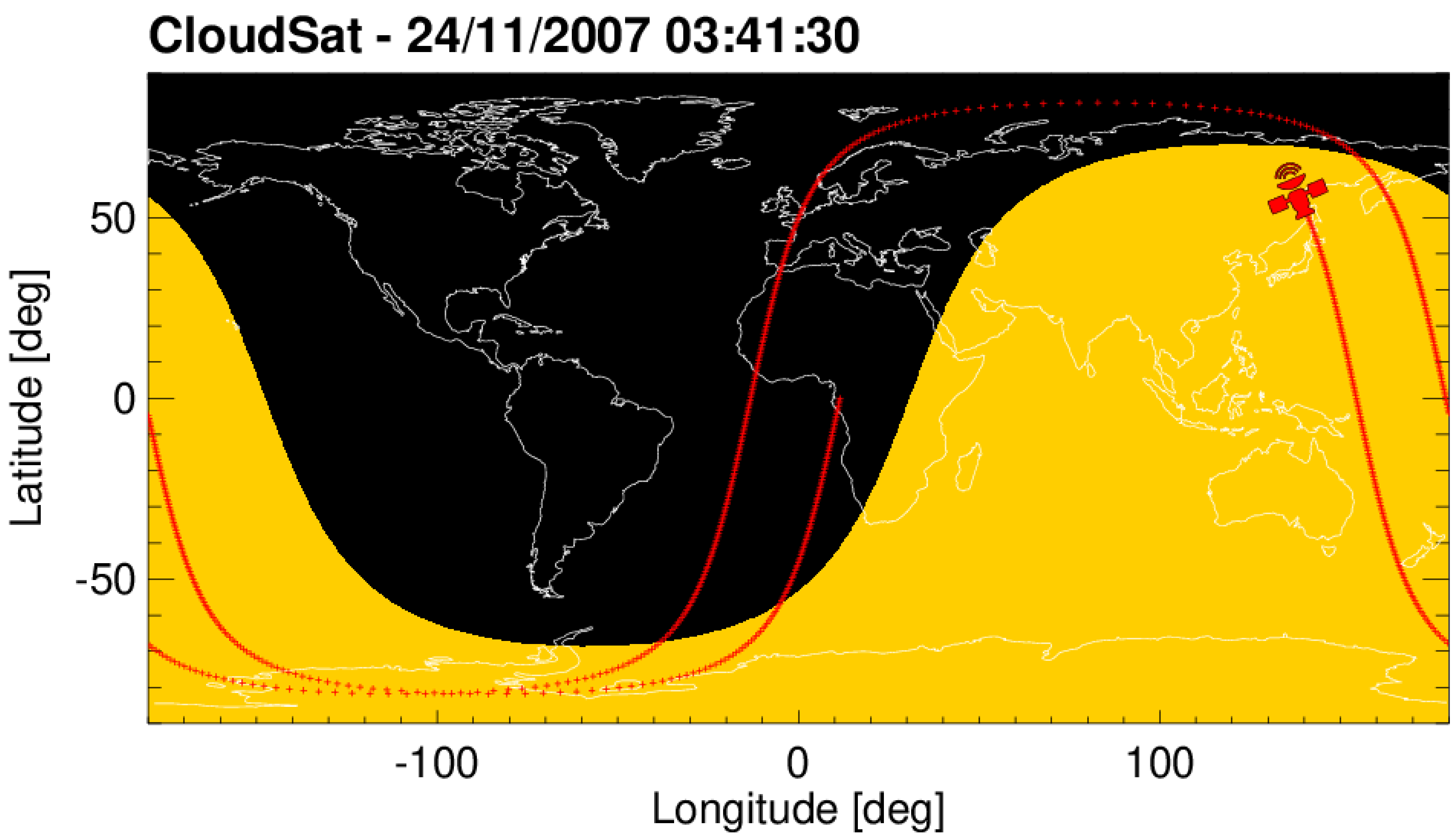
Footprint Characterization

Real-time extraction of geospatial information along a specified orbit path; coastline identification and convoluted DEM



Orbit Mapper

Real-time tracking of EarthCARE's sun-synchronous orbit location and phase (utilizing TLE information)



Sunlit = ascending / eclipse = descending

Tools

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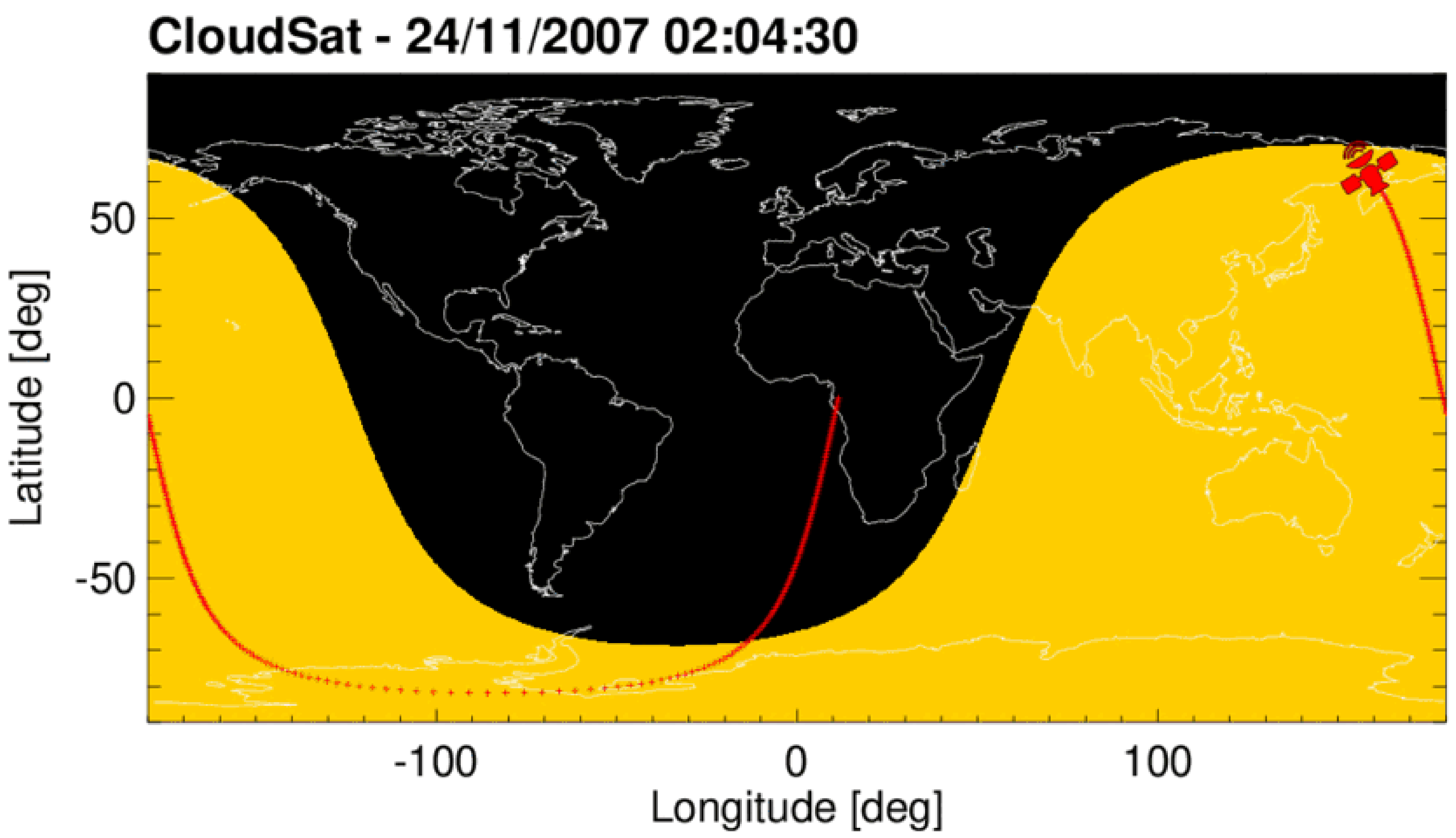

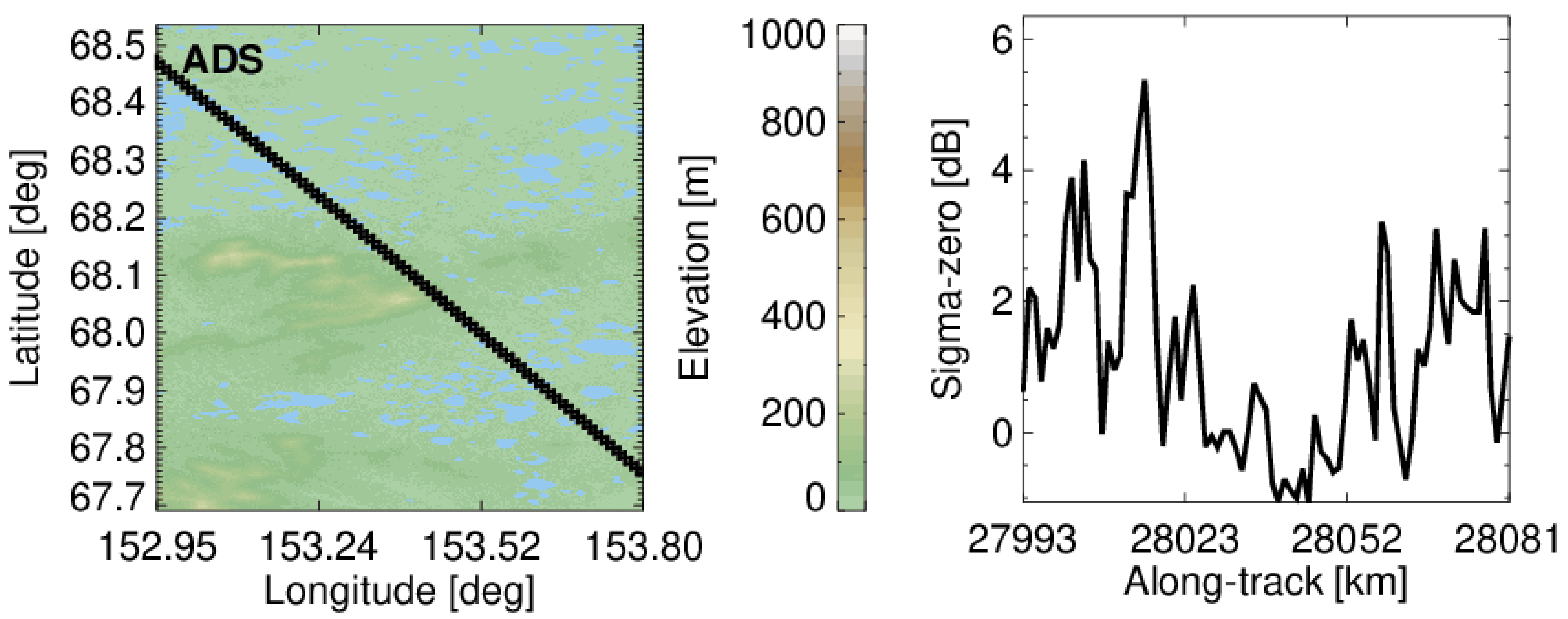

The signal captured by the instrument over the coastline is not always useful, it is often excessively noisy

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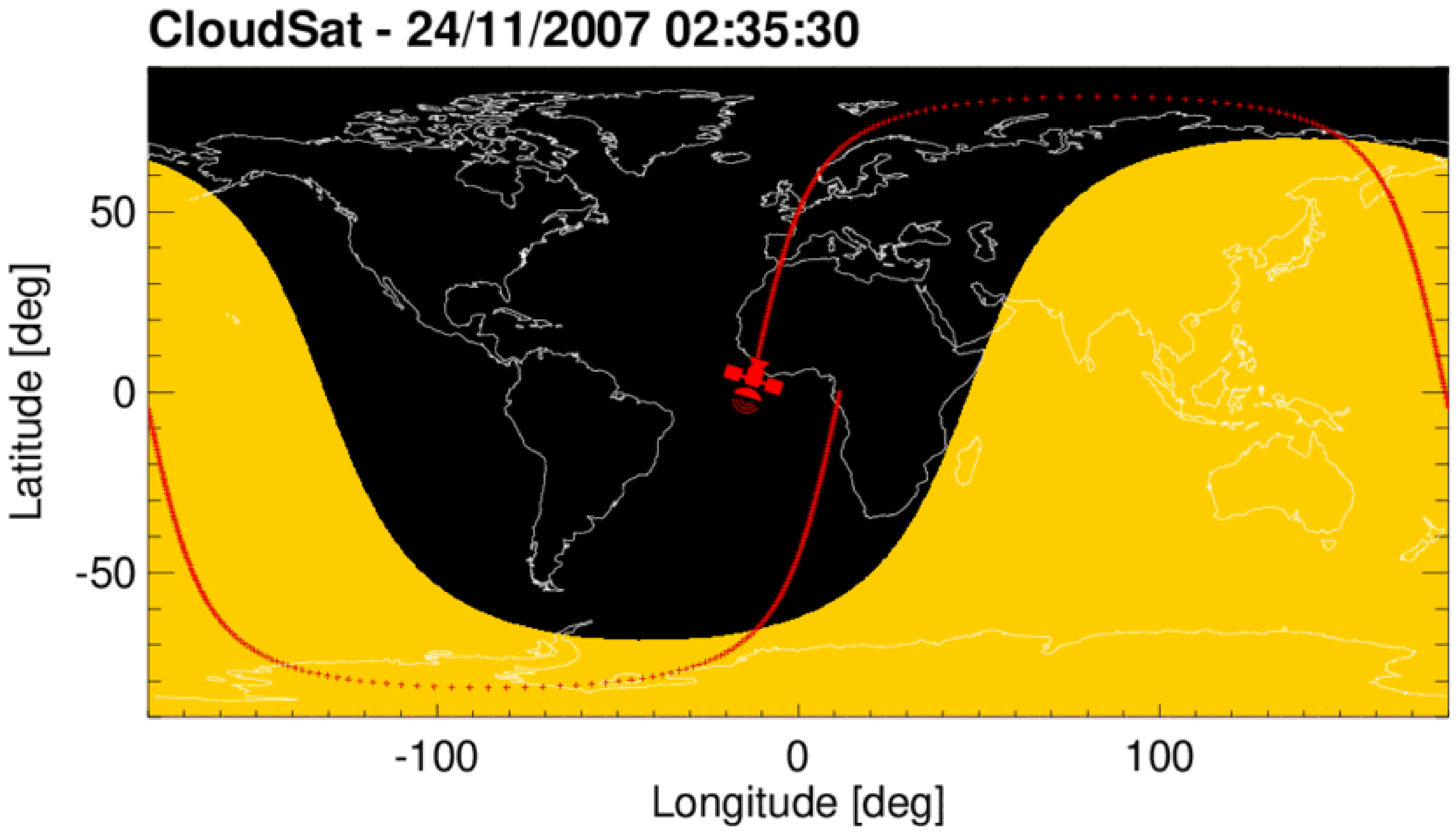

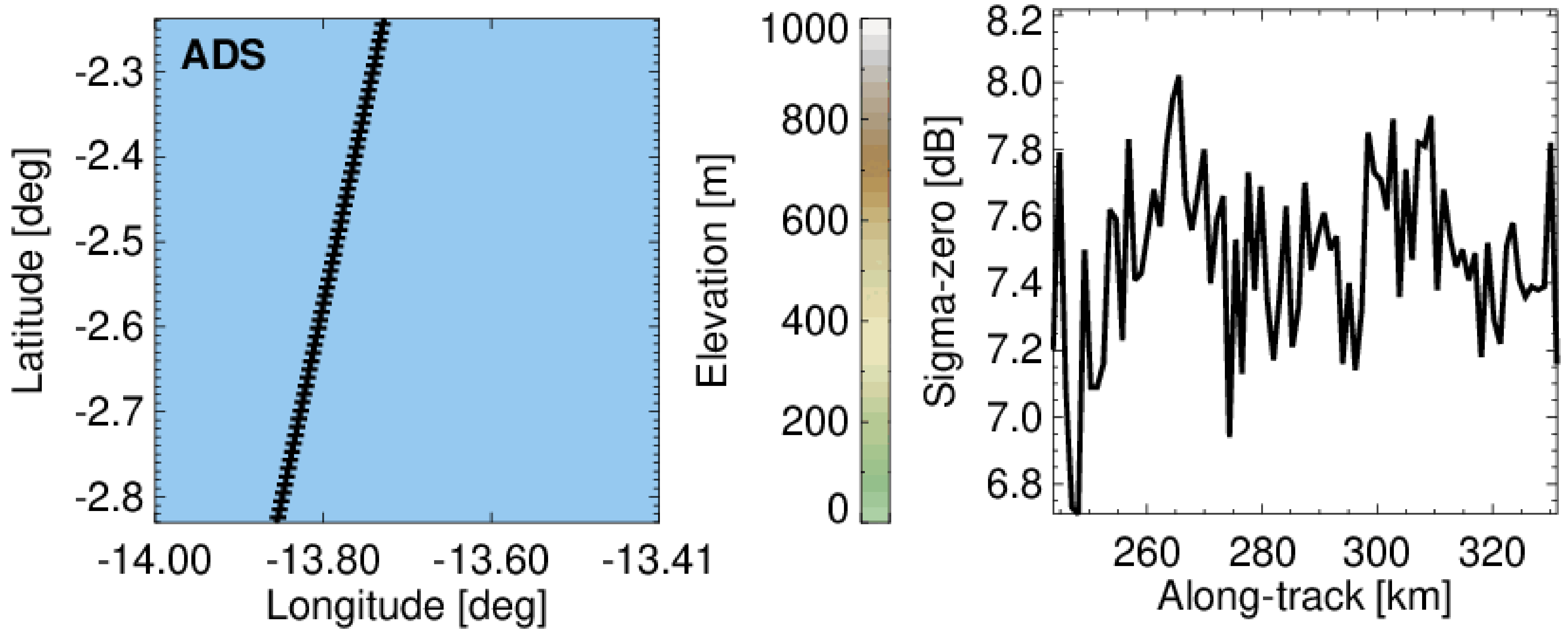

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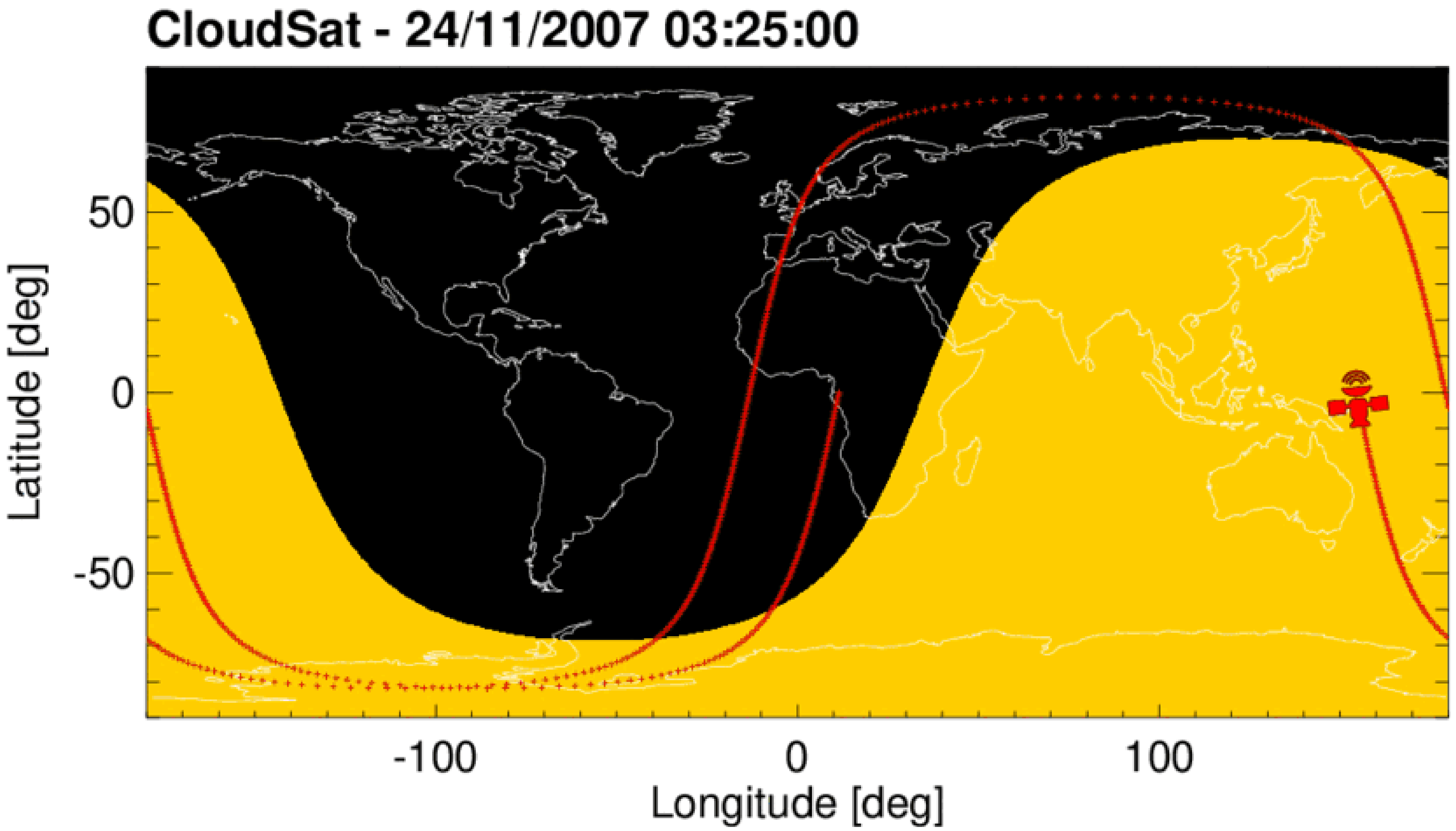
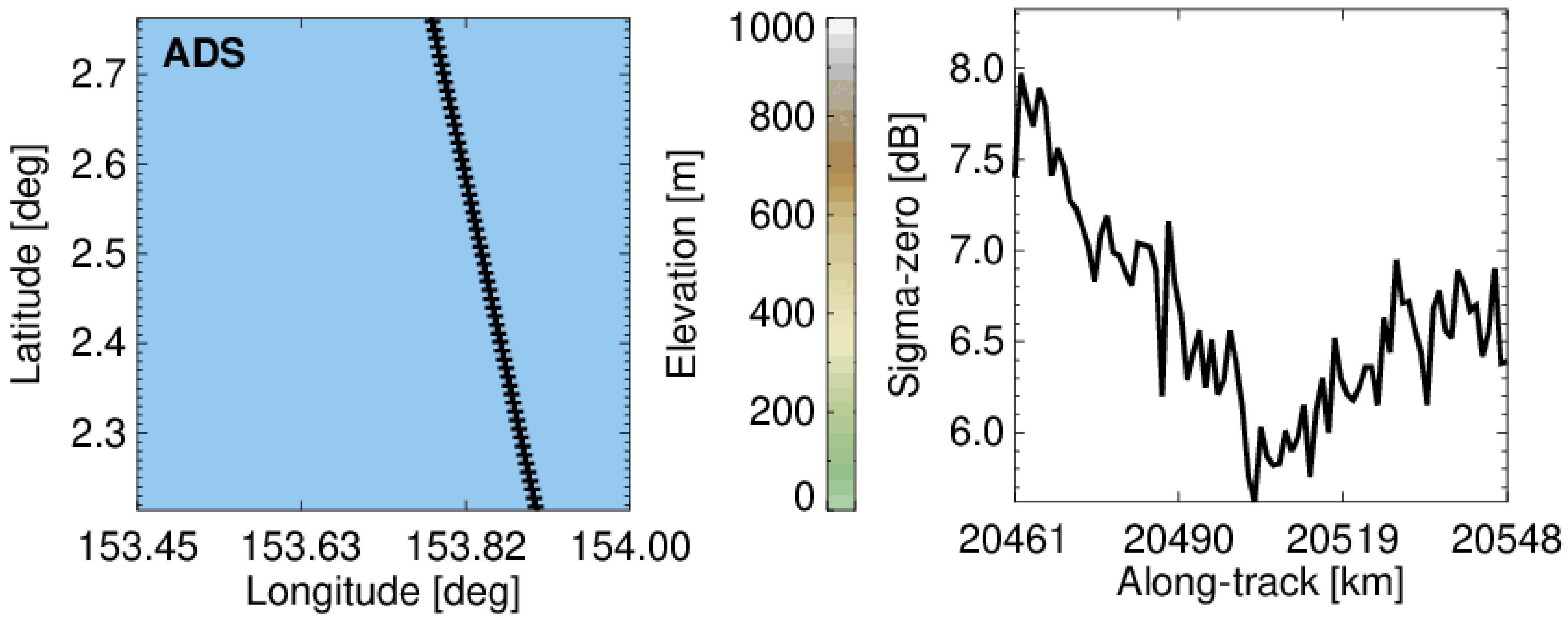




A clear ocean/land gradient must be available in order to effectively use the signal for the geolocation studies

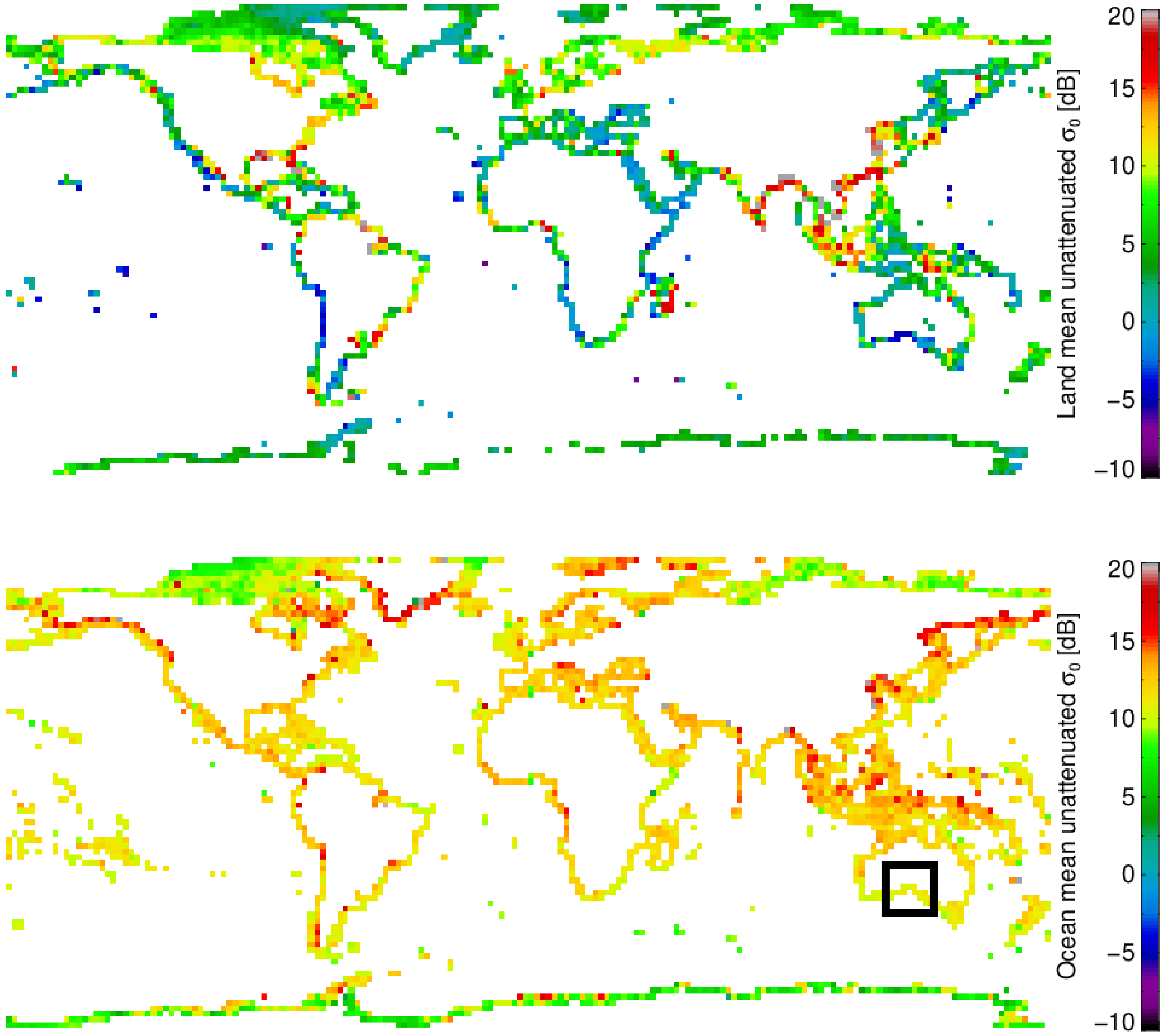
Identification of areas of interest

Clear coastlines

Identify coastal scenes with high gradients (i.e. flat deserts adjacent to ocean), using the CloudSat measured surface backscatter (**σ_0**)

Land

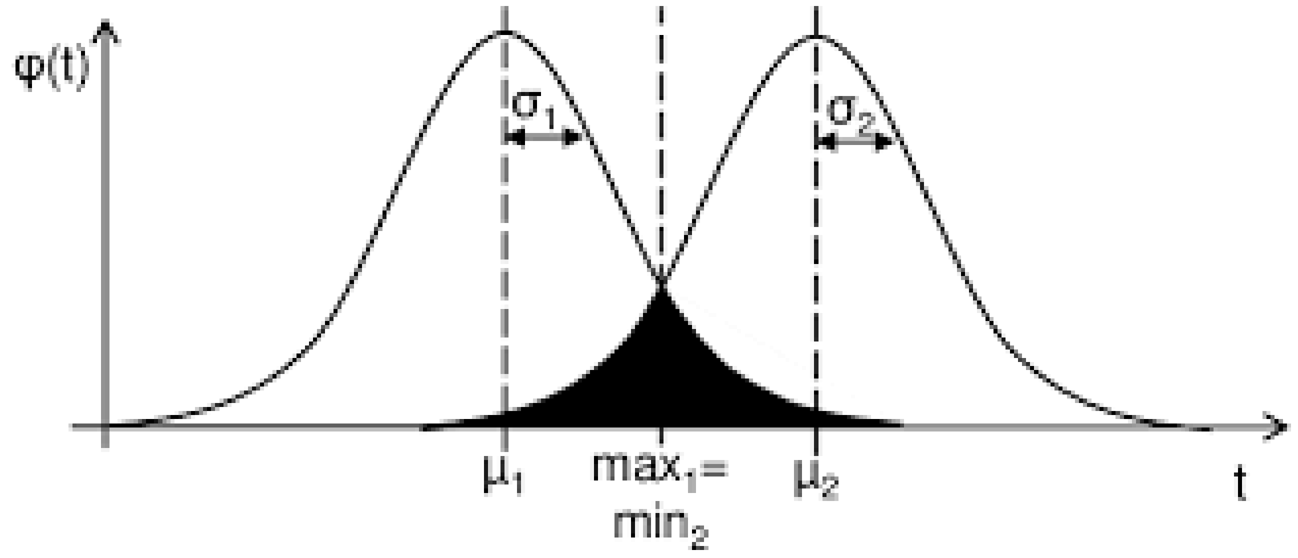
Ocean



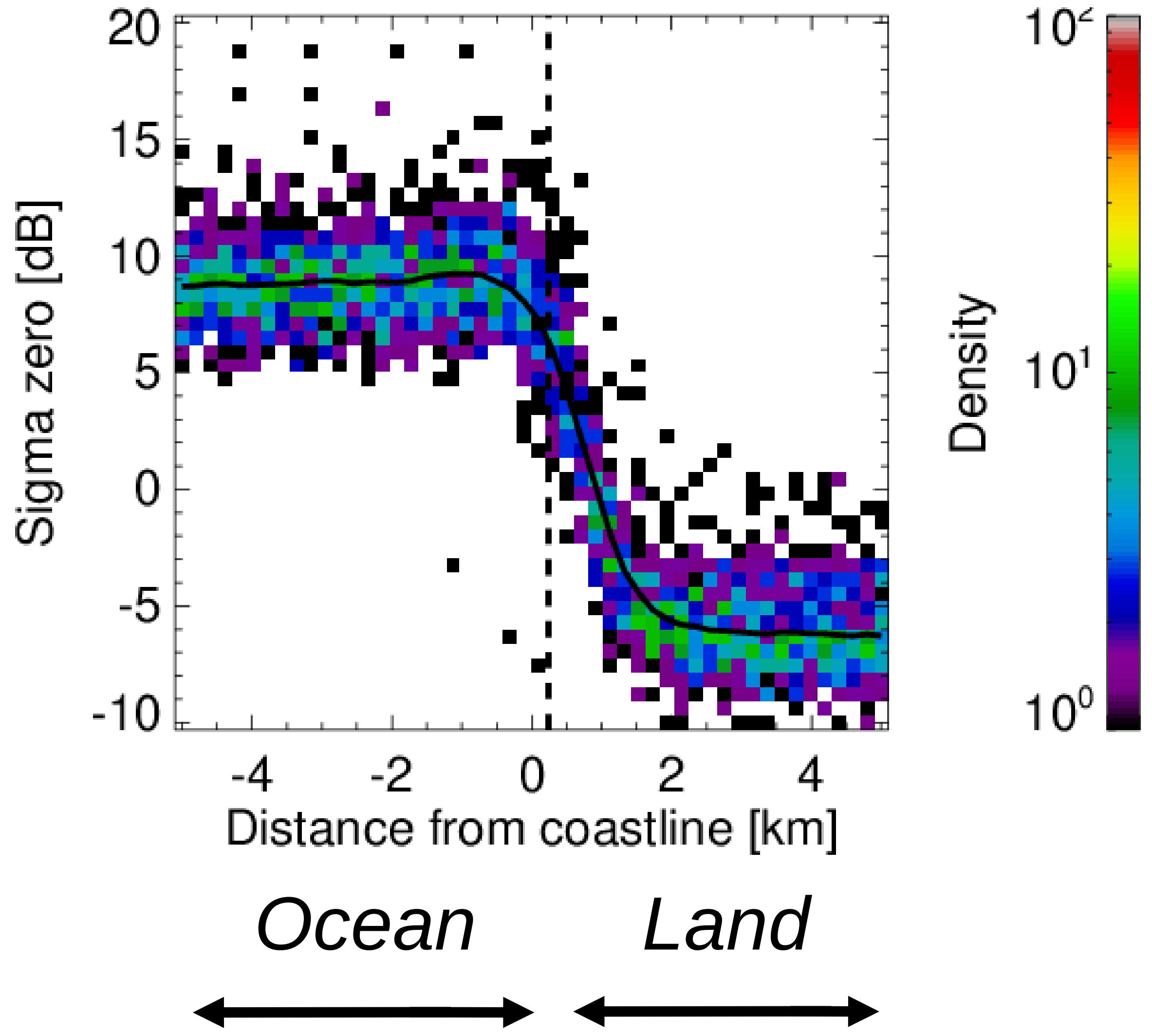
The sigma-zero distributions for land and ocean are characterized by their μ and σ. Optimal coastal scenes are identified by analyzing the distribution intersection, searching for regions with minimal overlap

Distribution overlapping area

Normalized value [0-1]



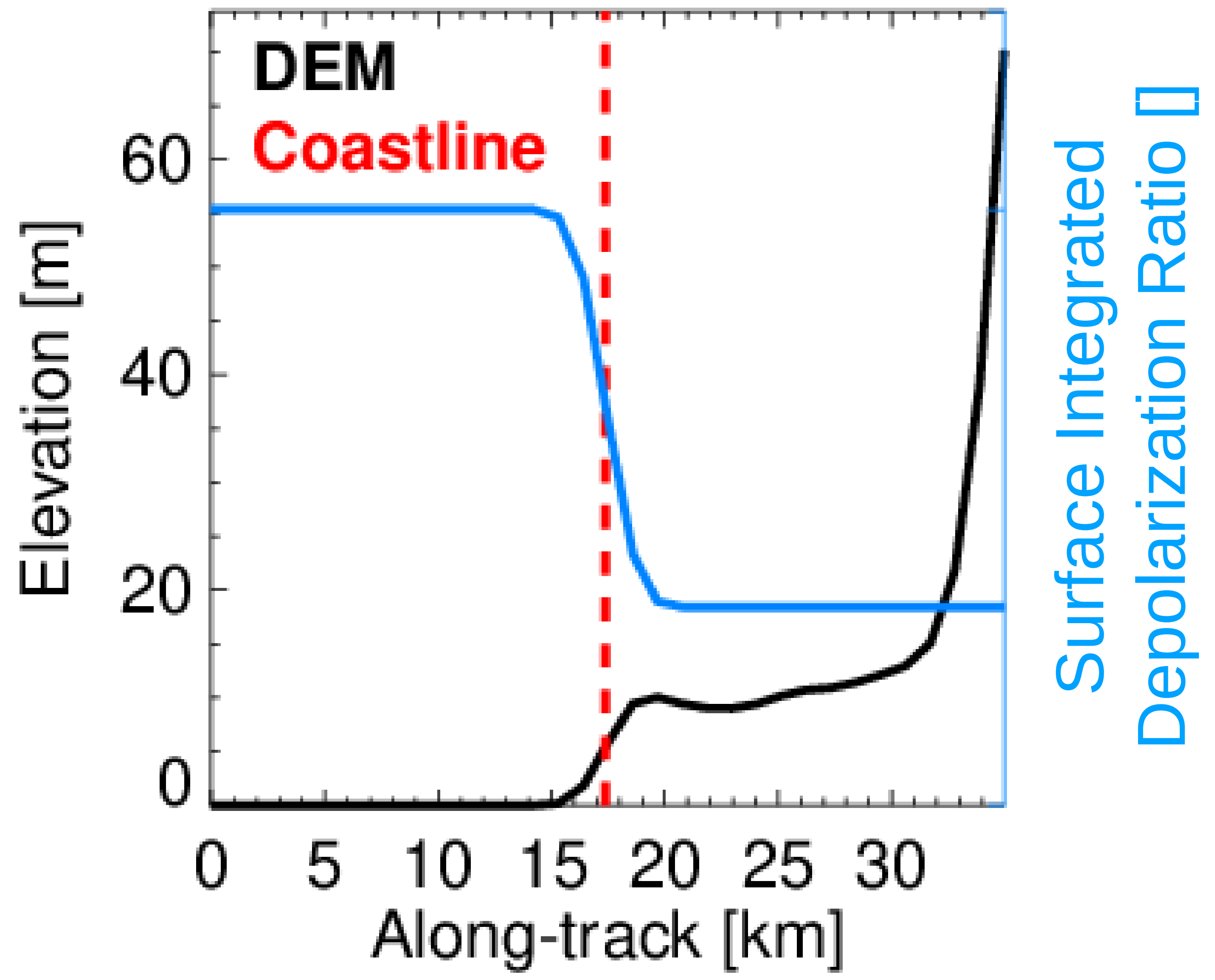
South Australia



Coastline geolocation

Geolocation Assessment Algorithm
for CALIPSO Using Coastline Detection

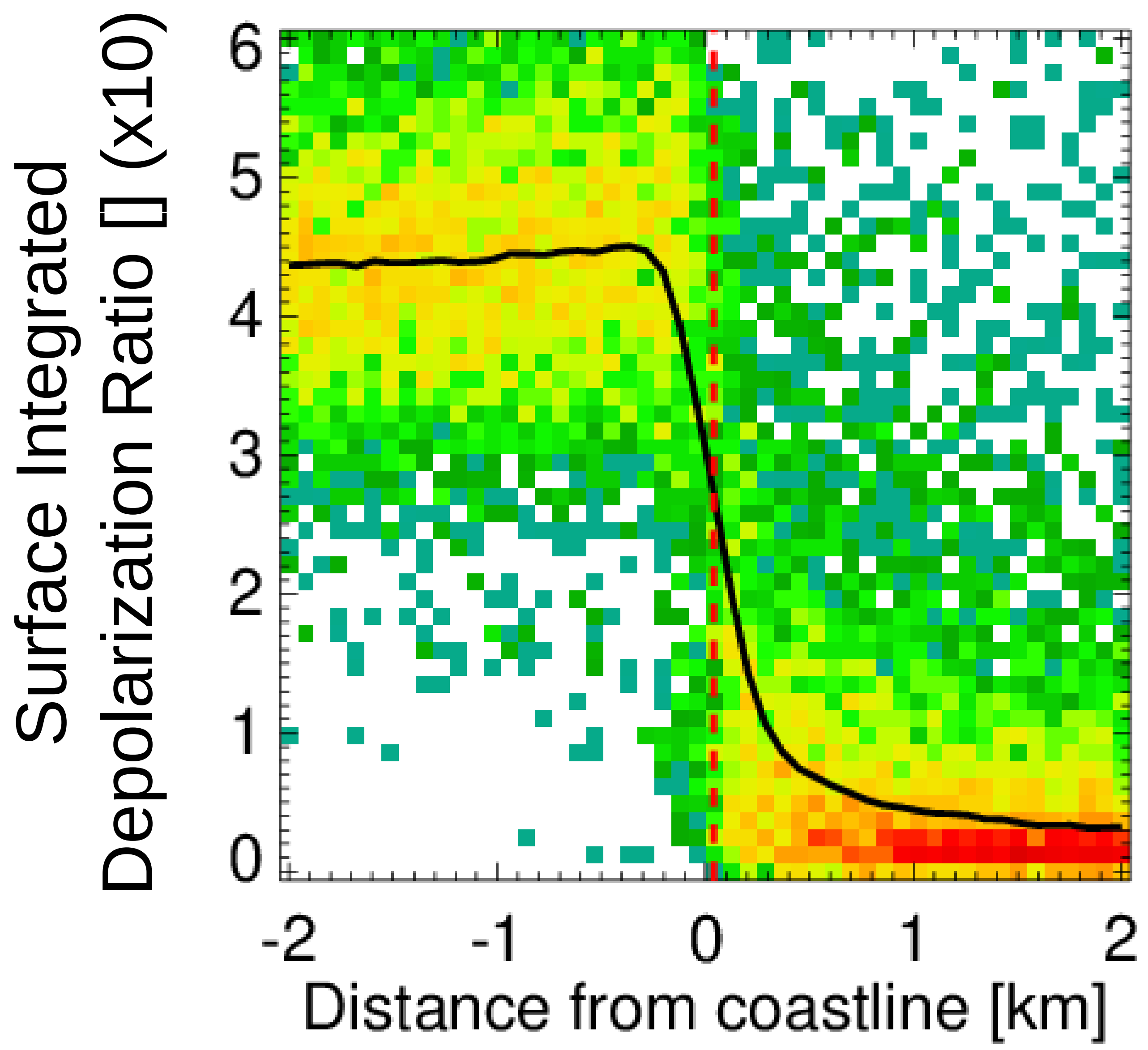
J. Chris Currey
Langley Research Center, Hampton, Virginia



The coastline signature is modelled using a cubic fit. The inflection point is considered to be the actual location of the coastline

CALIPSO

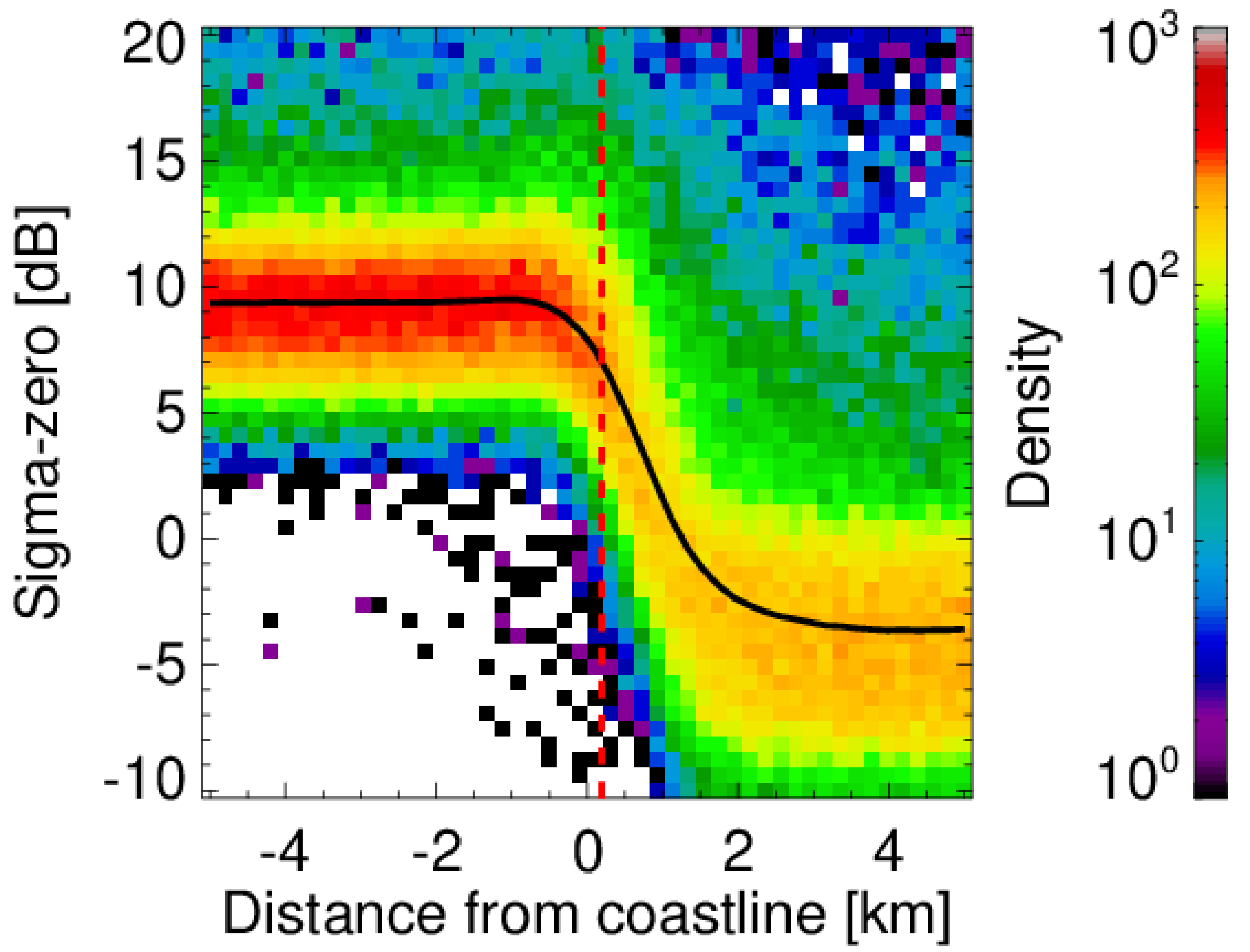
2007/12 - 2019/12
3º off-nadir along-track



Eclipse
35070 detections
Geolocation offset: 41m

CloudSat

2006/09 - 2019/12
0.16º off-nadir along-track



Eclipse
19328 detections
Geolocation offset: 197m

Coastline geolocation

Downhill simplex minimization approach

Fit an ensemble of detections to a digitalized map considered the truth. **The cost function minimizes the distance between the collection of detections and the map**

Coastline geolocation

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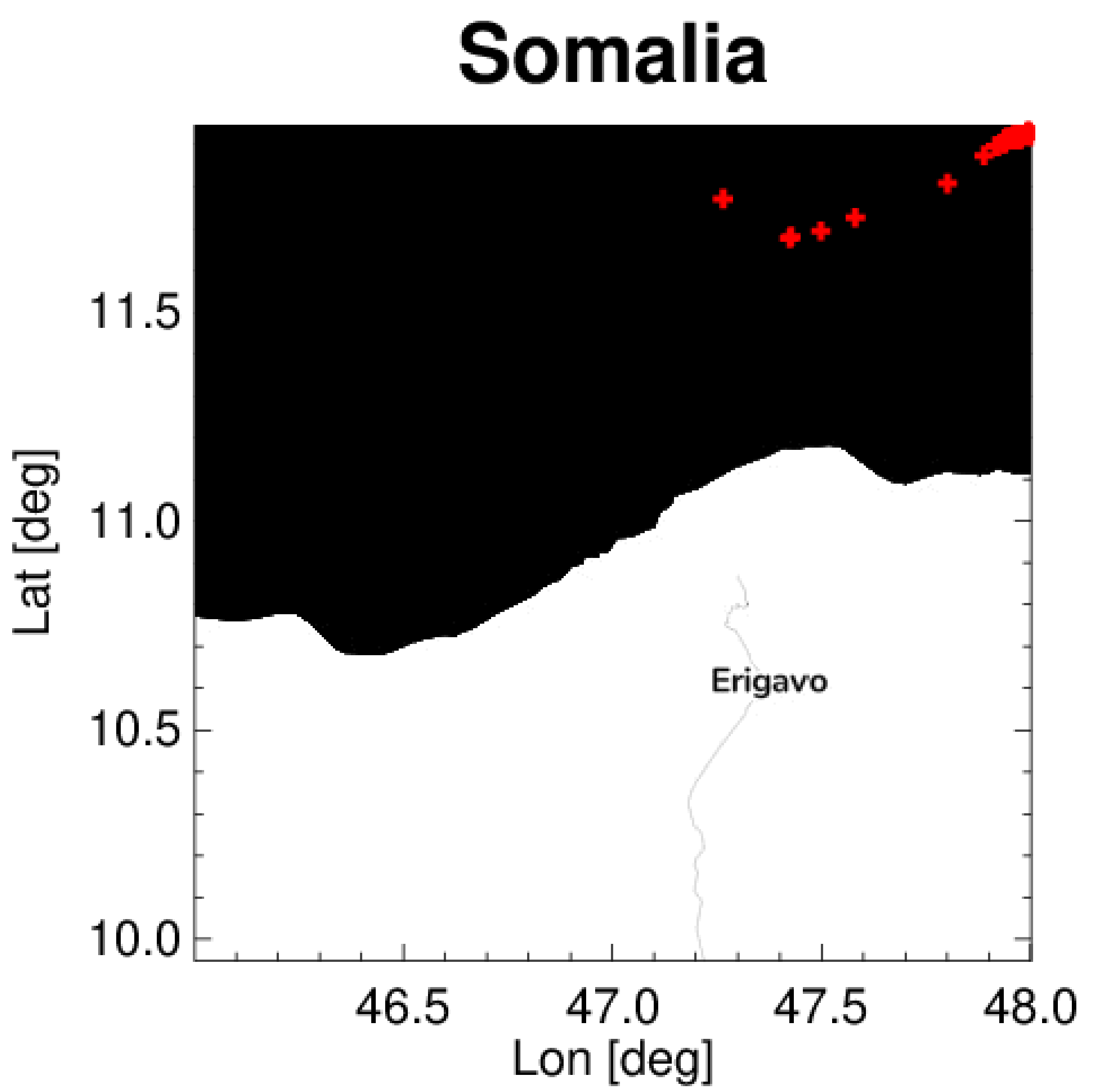

N detections: 180
Orbit tilt: 167° (N-W)
Iteration: 1
Cross-track offset: +10.586° ~ +131758m
Along-track offset: +6.798° ~ +84046m

Coastline geolocation

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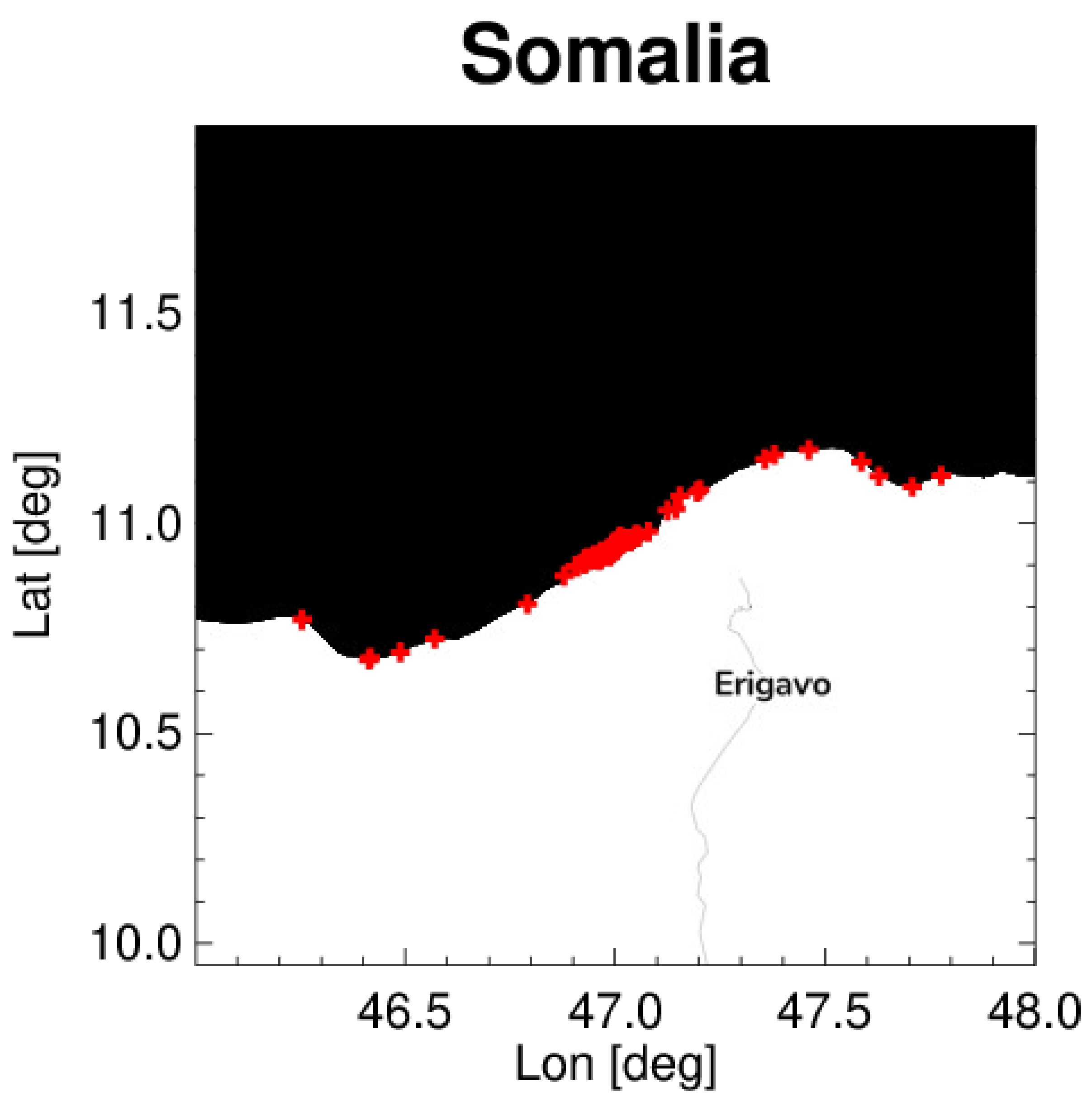
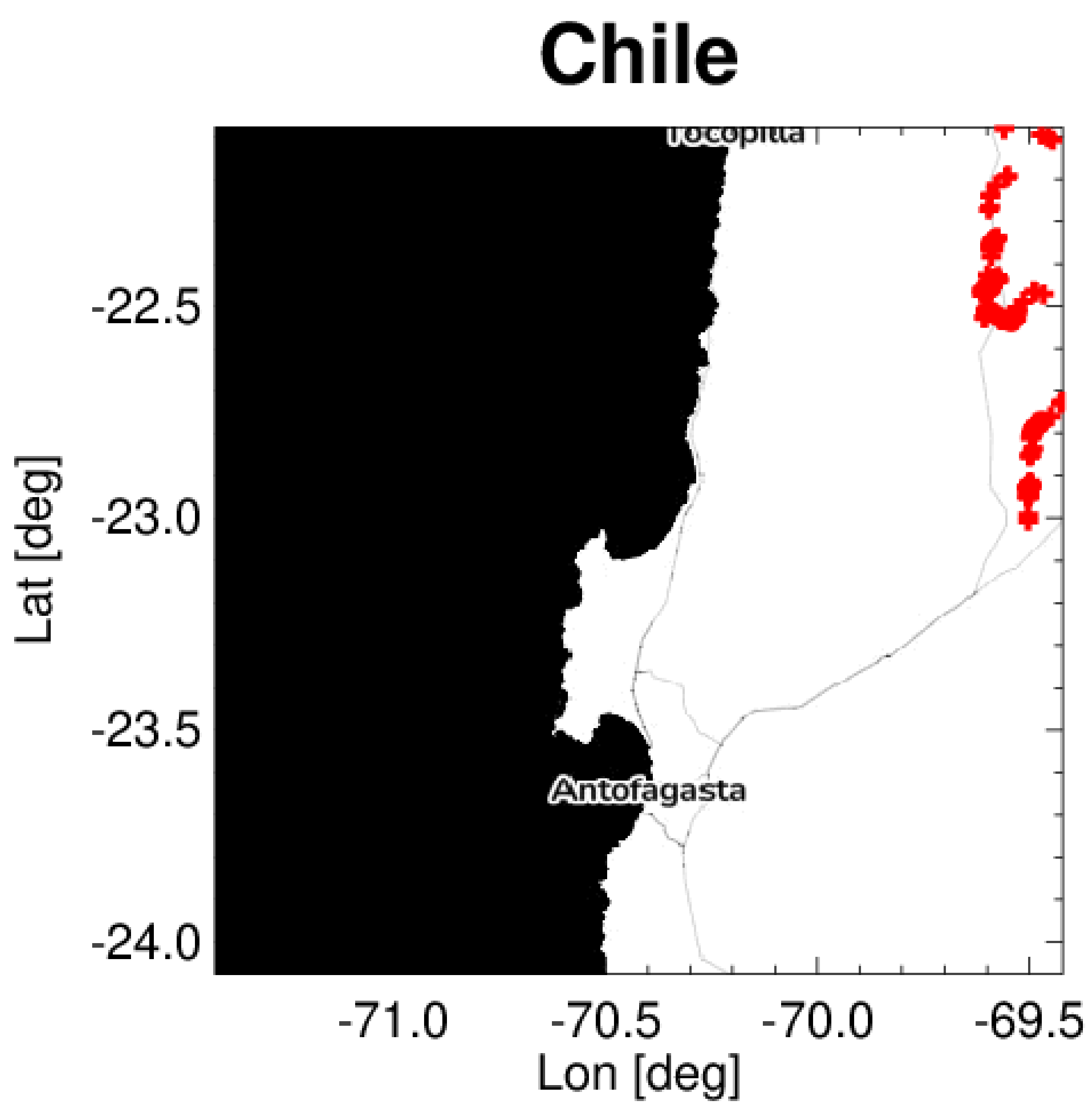
Fit an ensemble of detections to a digitalized map considered the truth. **The cost function minimizes the distance between the collection of detections and the map**



N detections: 180
Orbit tilt: 167° (N-W)
Iteration: 71
Cross-track offset: -0.001° ~ -9m
Along-track offset: +0.001° ~ +10m



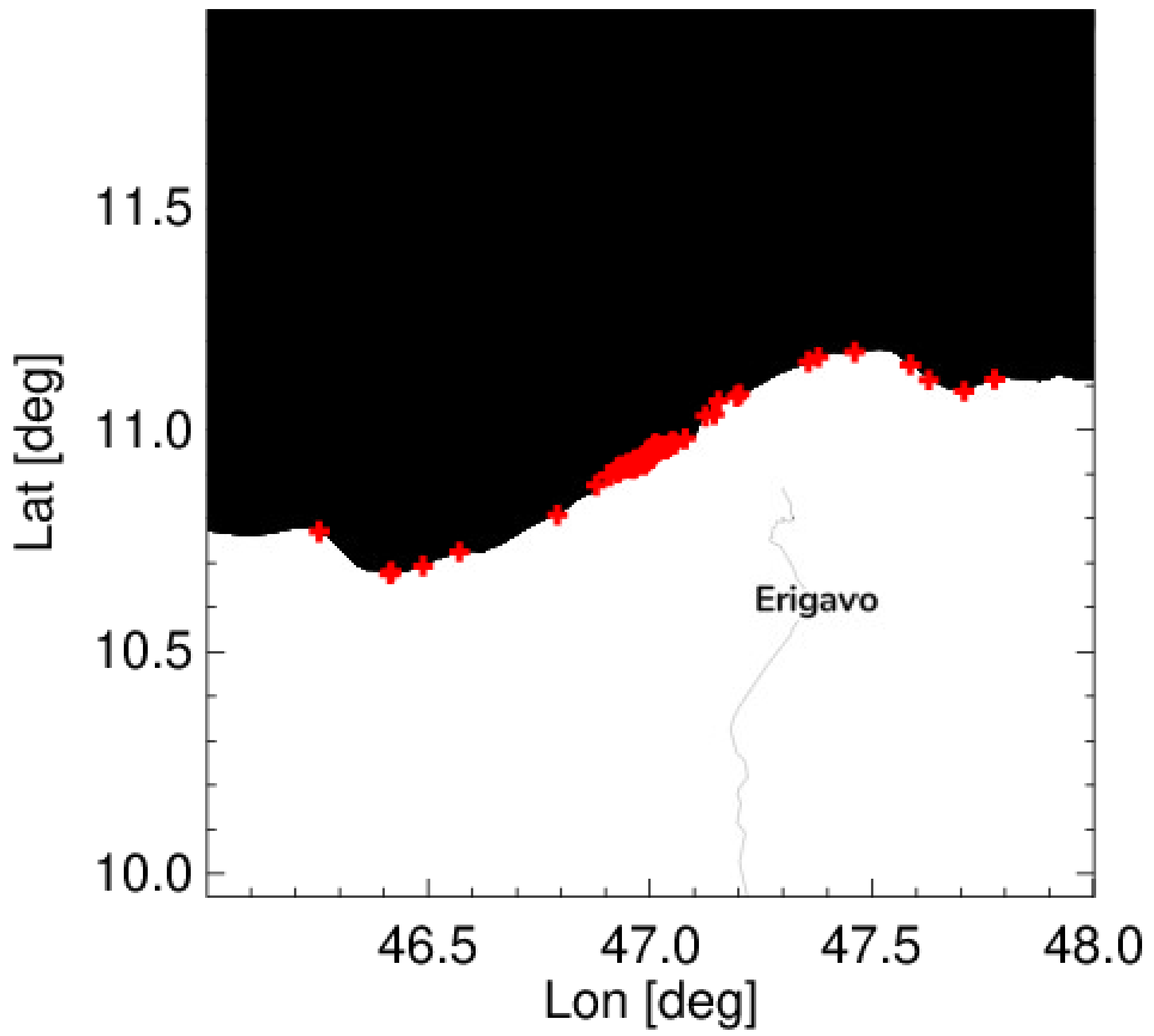
N detections: 205
Orbit tilt: 166° (N-W)
Iteration: 1
Cross-track offset: +10.125° ~ +125897m
Along-track offset: +6.826° ~ +84396m

Coastline geolocation

Downhill simplex minimization approach

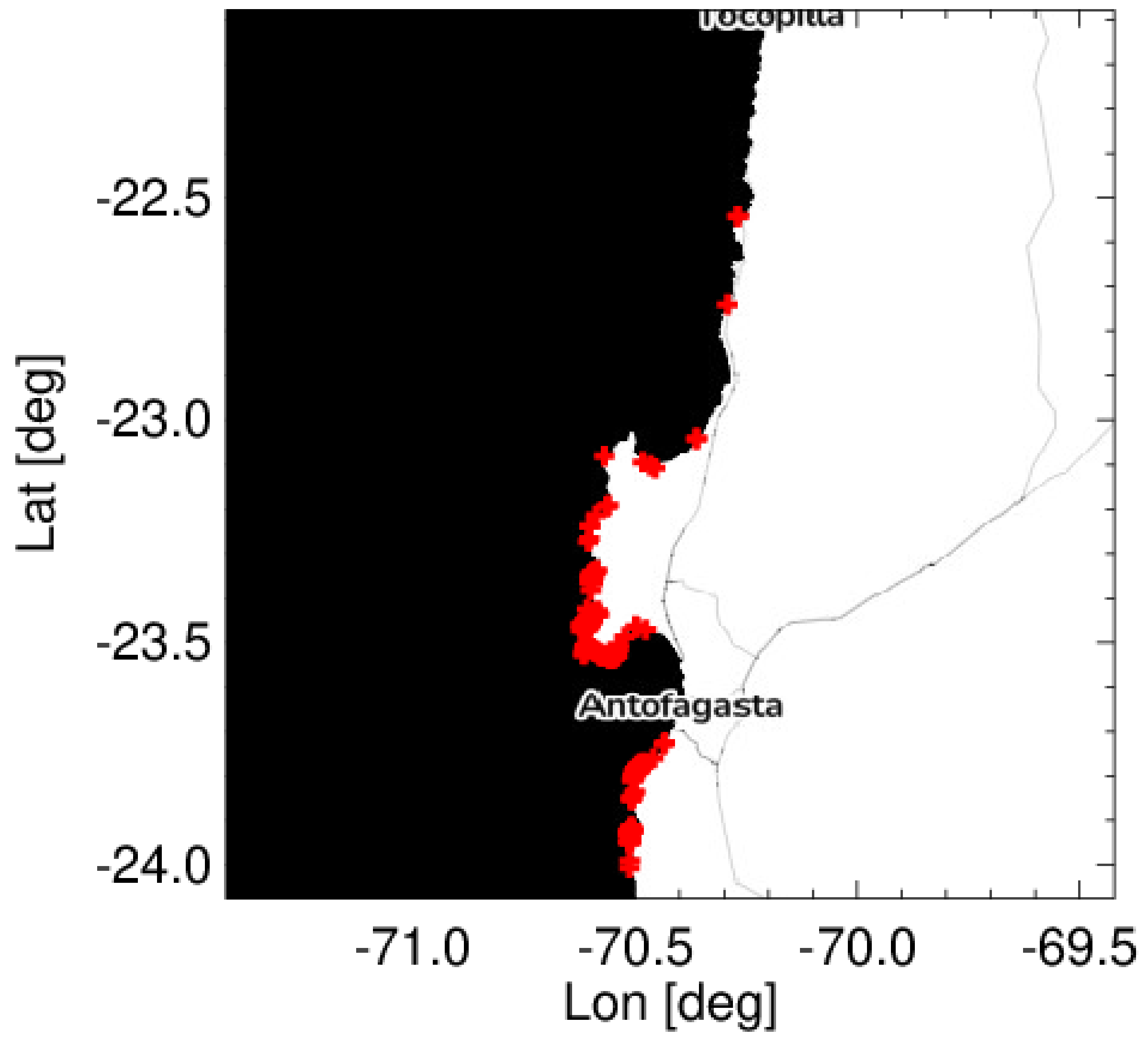
Fit an ensemble of detections to a digitalized map considered the truth. **The cost function minimizes the distance between the collection of detections and the map**

Somalia



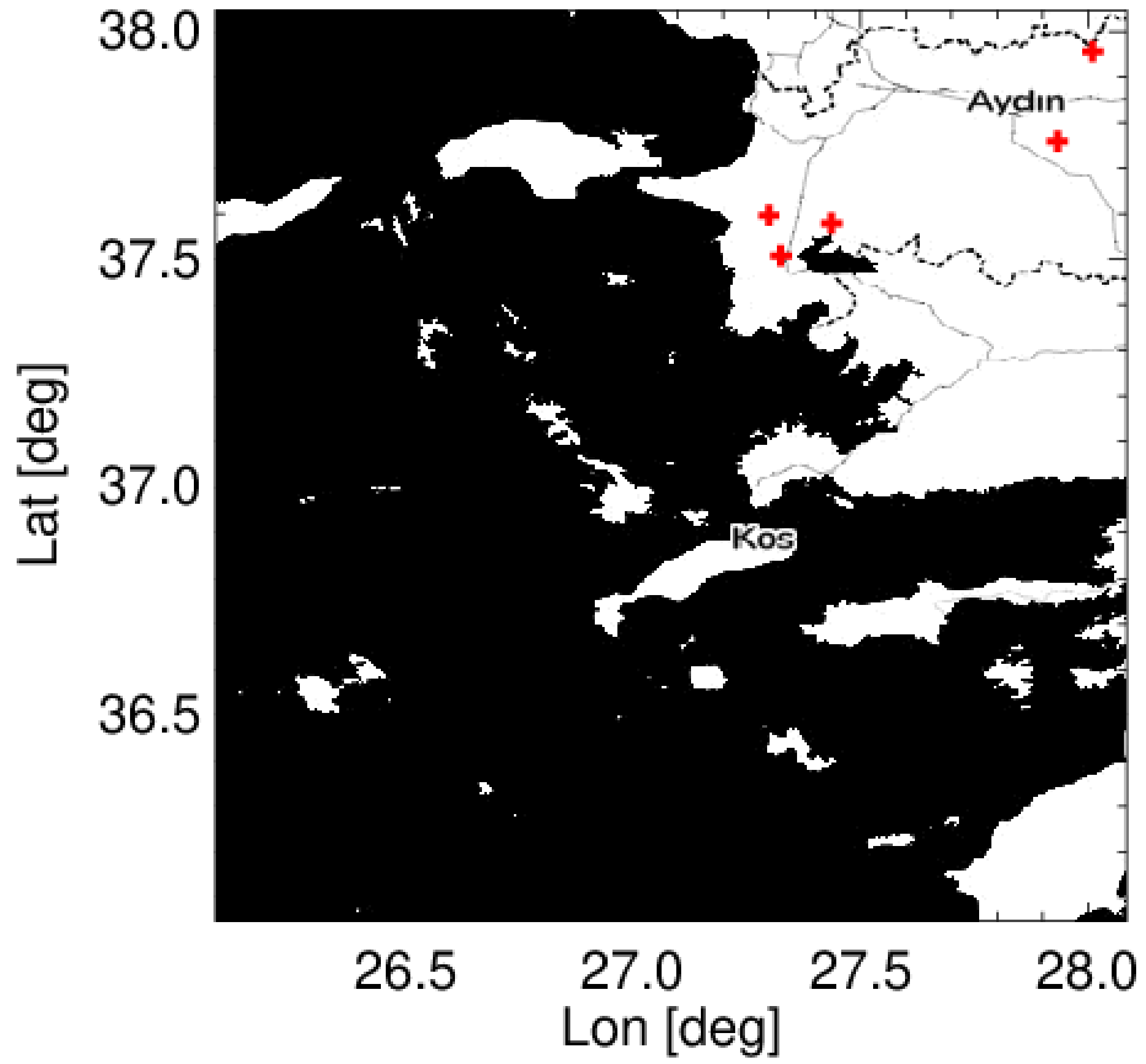
N detections: 180
Orbit tilt: 167° (N-W)
Iteration: 71
Cross-track offset: -0.001° ~ -9m
Along-track offset: +0.001° ~ +10m

Chile



N detections: 205
Orbit tilt: 166° (N-W)
Iteration: 62
Cross-track offset: +0.001° ~ +7m
Along-track offset: +0.002° ~ +24m

Greece

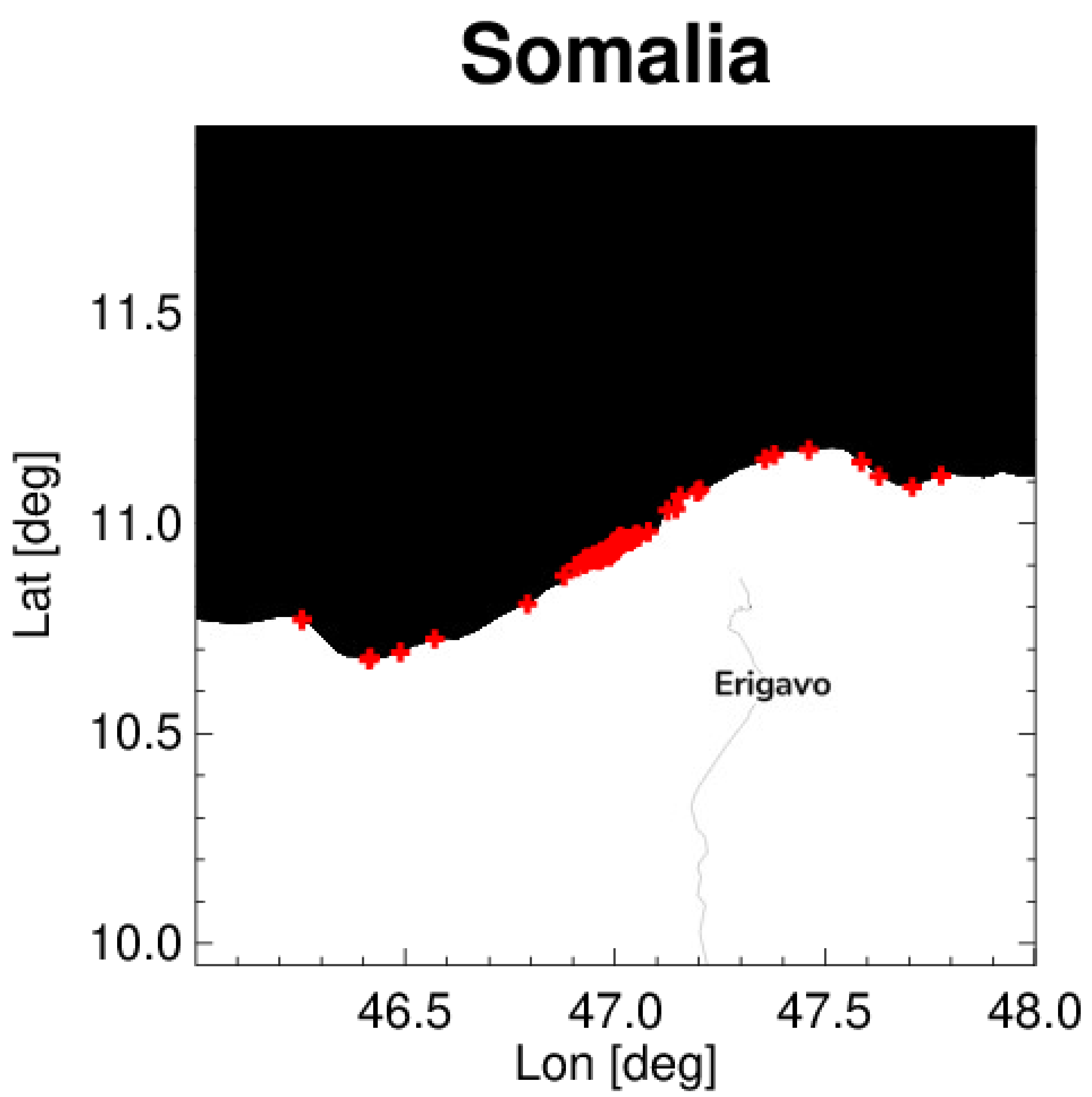


N detections: 119
Orbit tilt: 166° (N-W)
Iteration: 1
Cross-track offset: +9.108° ~ +113025m
Along-track offset: +7.056° ~ +87267m

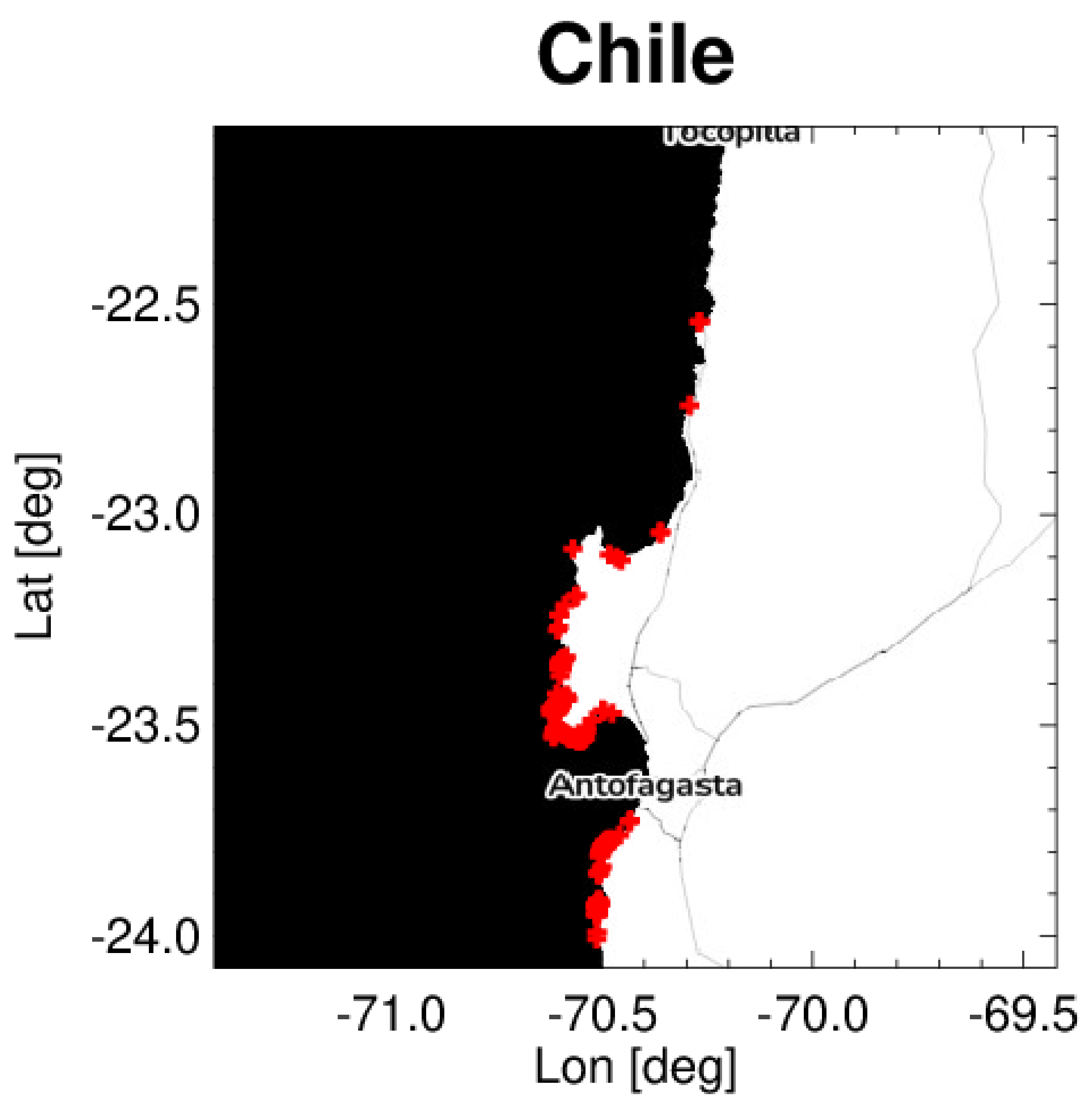
Coastline geolocation

Downhill simplex minimization approach

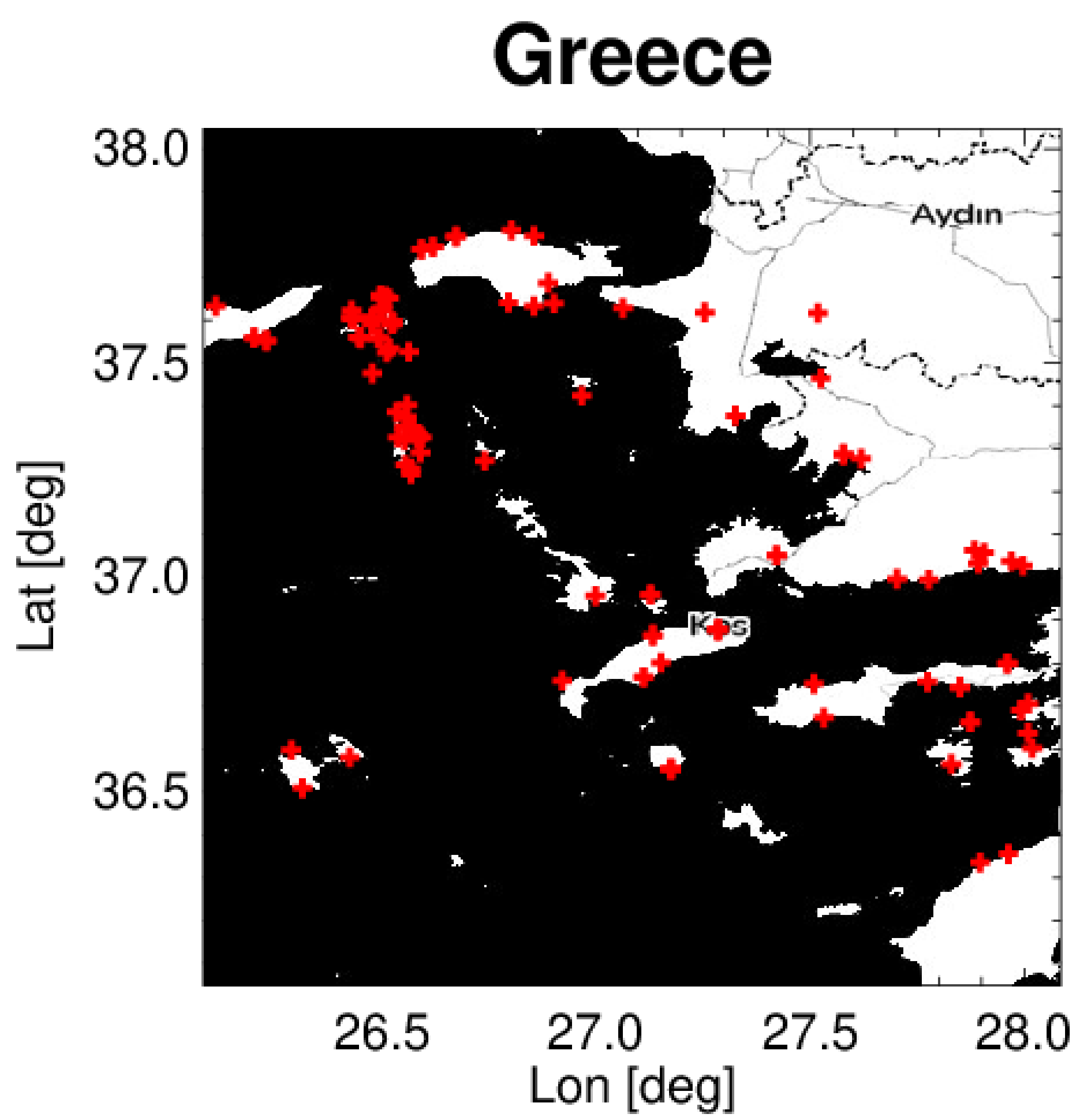
Fit an ensemble of detections to a digitalized map considered the truth. **The cost function minimizes the distance between the collection of detections and the map**



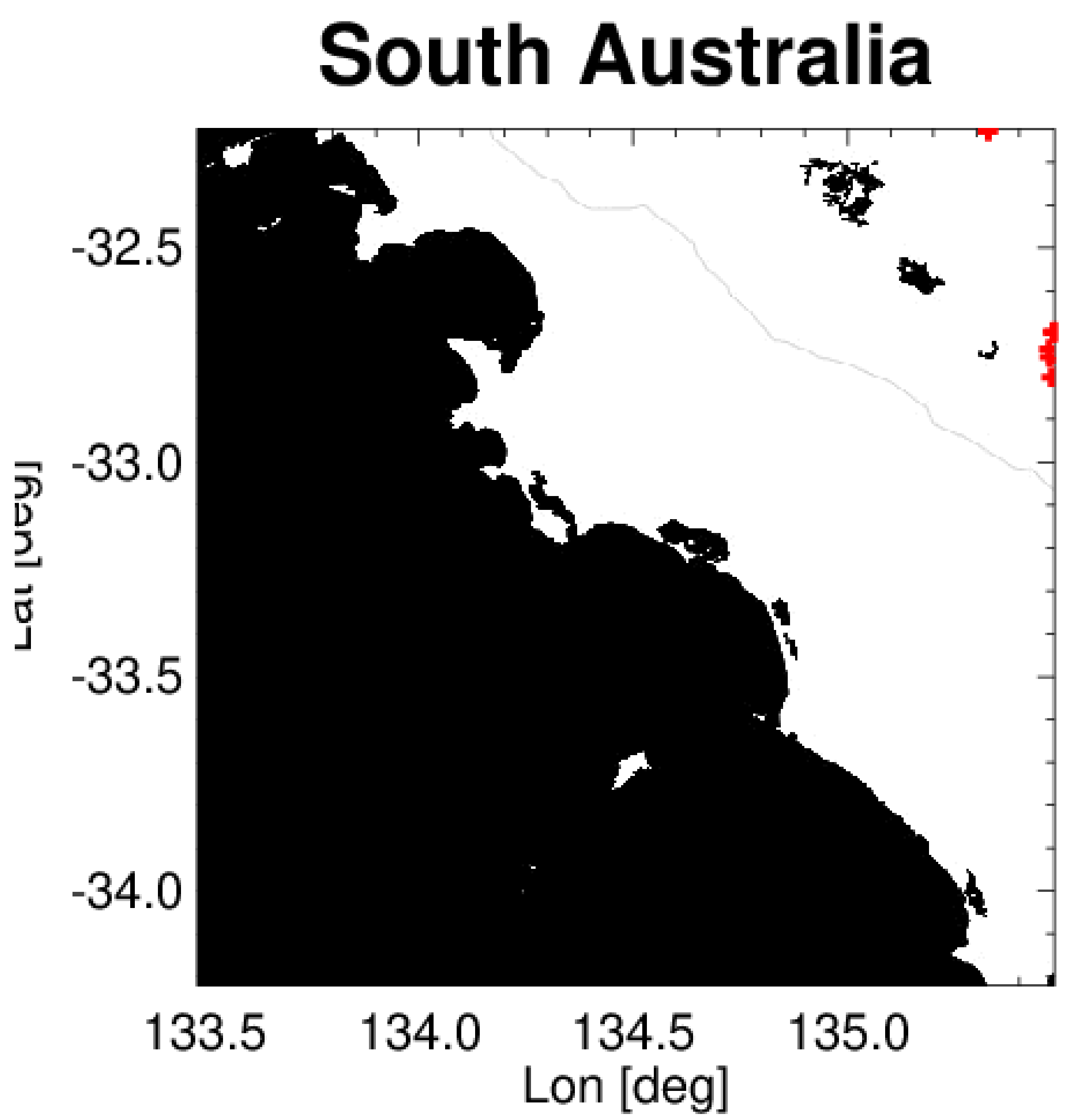
N detections: 180
Orbit tilt: 167° (N-W)
Iteration: 71
Cross-track offset: -0.001° ~ -9m
Along-track offset: +0.001° ~ +10m



N detections: 205
Orbit tilt: 166° (N-W)
Iteration: 62
Cross-track offset: +0.001° ~ +7m
Along-track offset: +0.002° ~ +24m



N detections: 119
Orbit tilt: 166° (N-W)
Iteration: 64
Cross-track offset: -0.002° ~ -26m
Along-track offset: +0.003° ~ +42m



N detections: 503
Orbit tilt: 166° (N-W)
Iteration: 1
Cross-track offset: +9.452° ~ +117371m
Along-track offset: +6.951° ~ +85946m

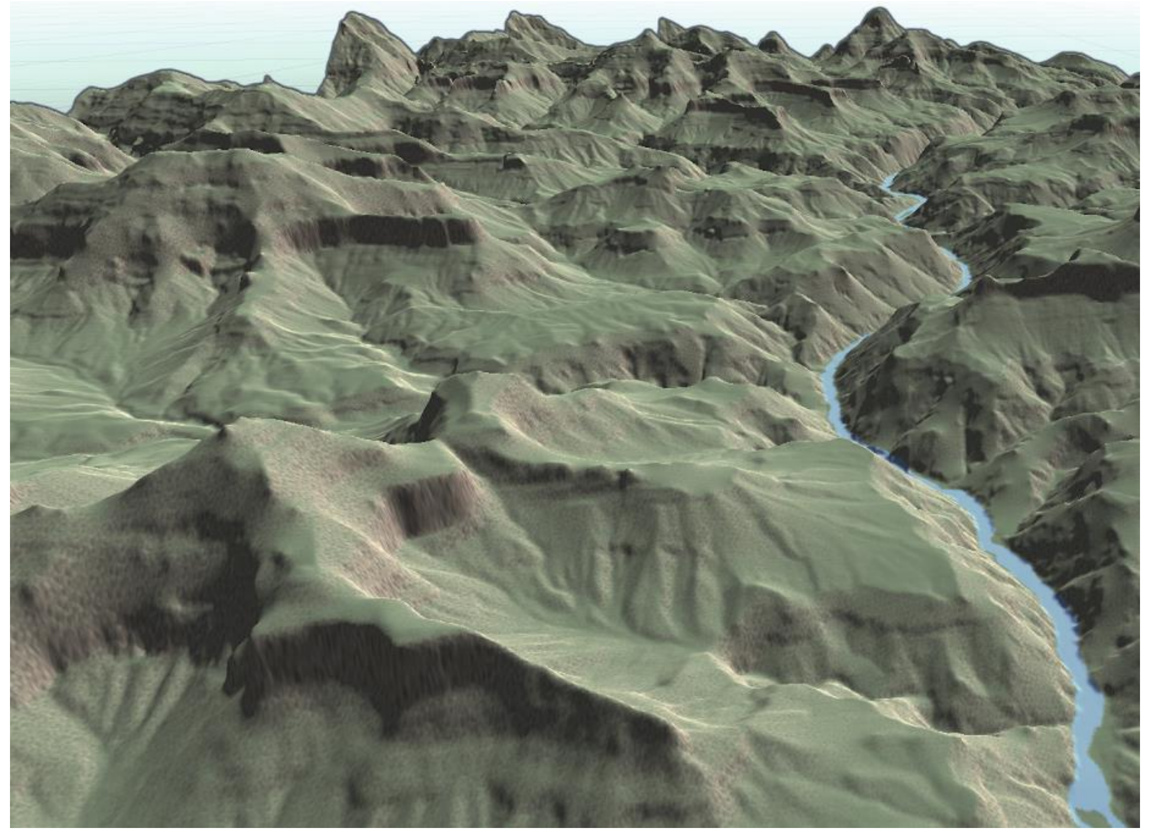
Identification of areas of interest

Significant elevation gradients

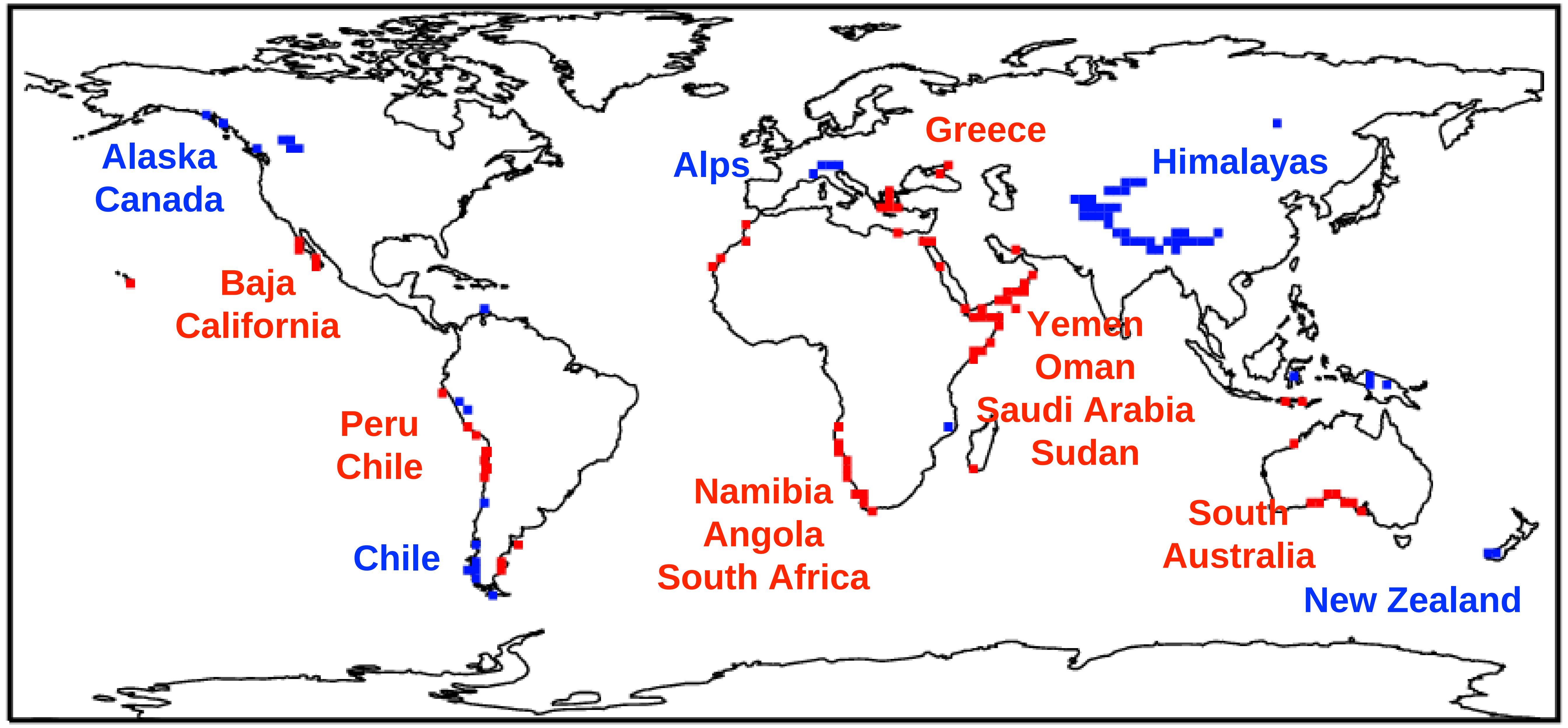
Areas with significant elevation gradients, such as mountains and valleys, identified by convoluting the global DEM with the EarthCARE CPR footprint and selecting the regions that exhibit a higher number of σ points surpassing the threshold of 100m

CloudSat's Cloud Profiling Radar After Two Years in Orbit: Performance, Calibration, and Processing

Simone Tanelli, Stephen L. Durden, *Senior Member, IEEE*, Eastwood Im, *Fellow, IEEE*, Kyung S. Pak, Dale G. Reinke, Philip Partain, John M. Haynes, and Roger T. Marchand



Compare the instrument's surface detection height to the reference DEM



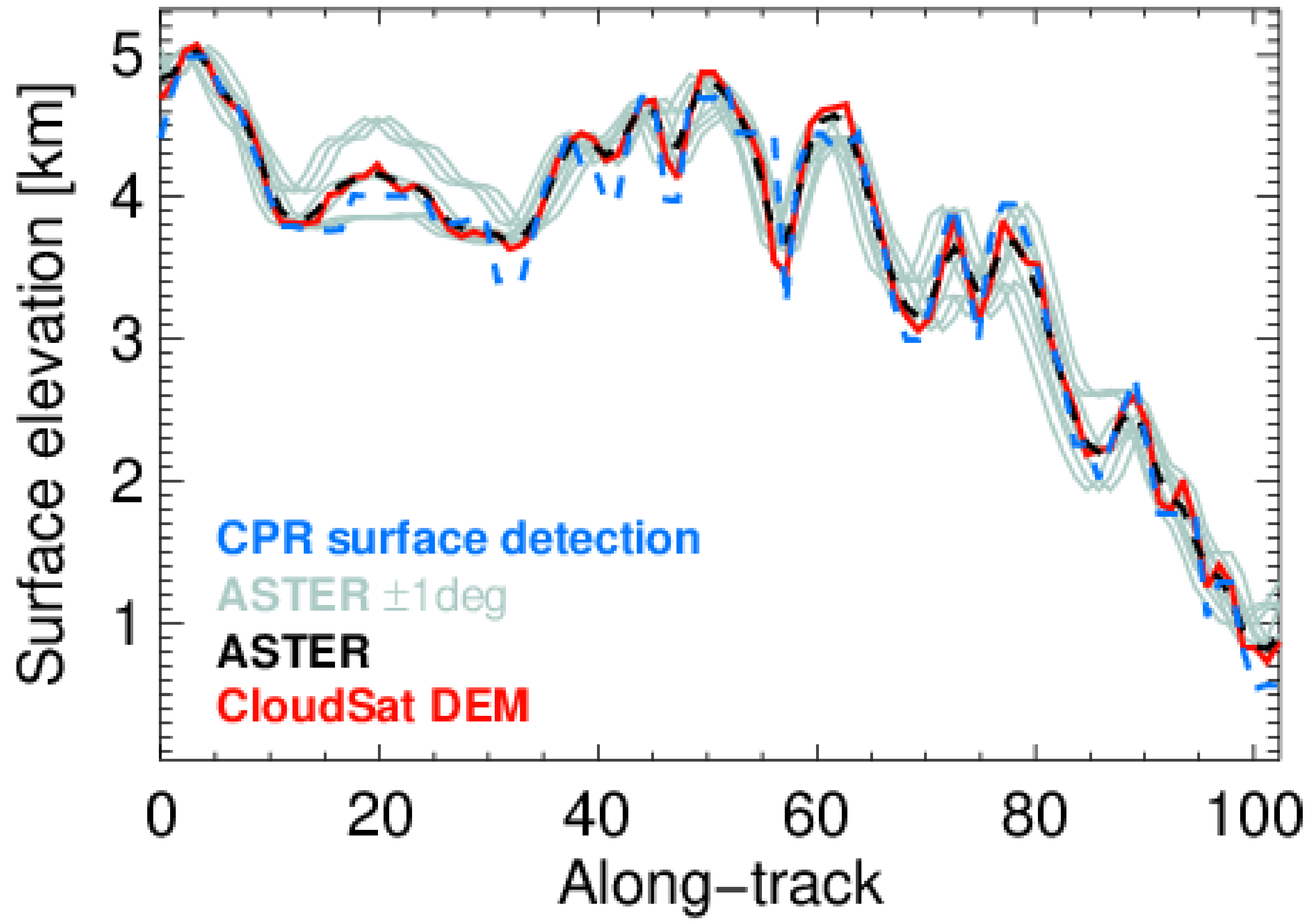
Clear coastlines

Areas with with significant elevation gradients

Significant elevation gradients geolocation

Significant elevation gradients

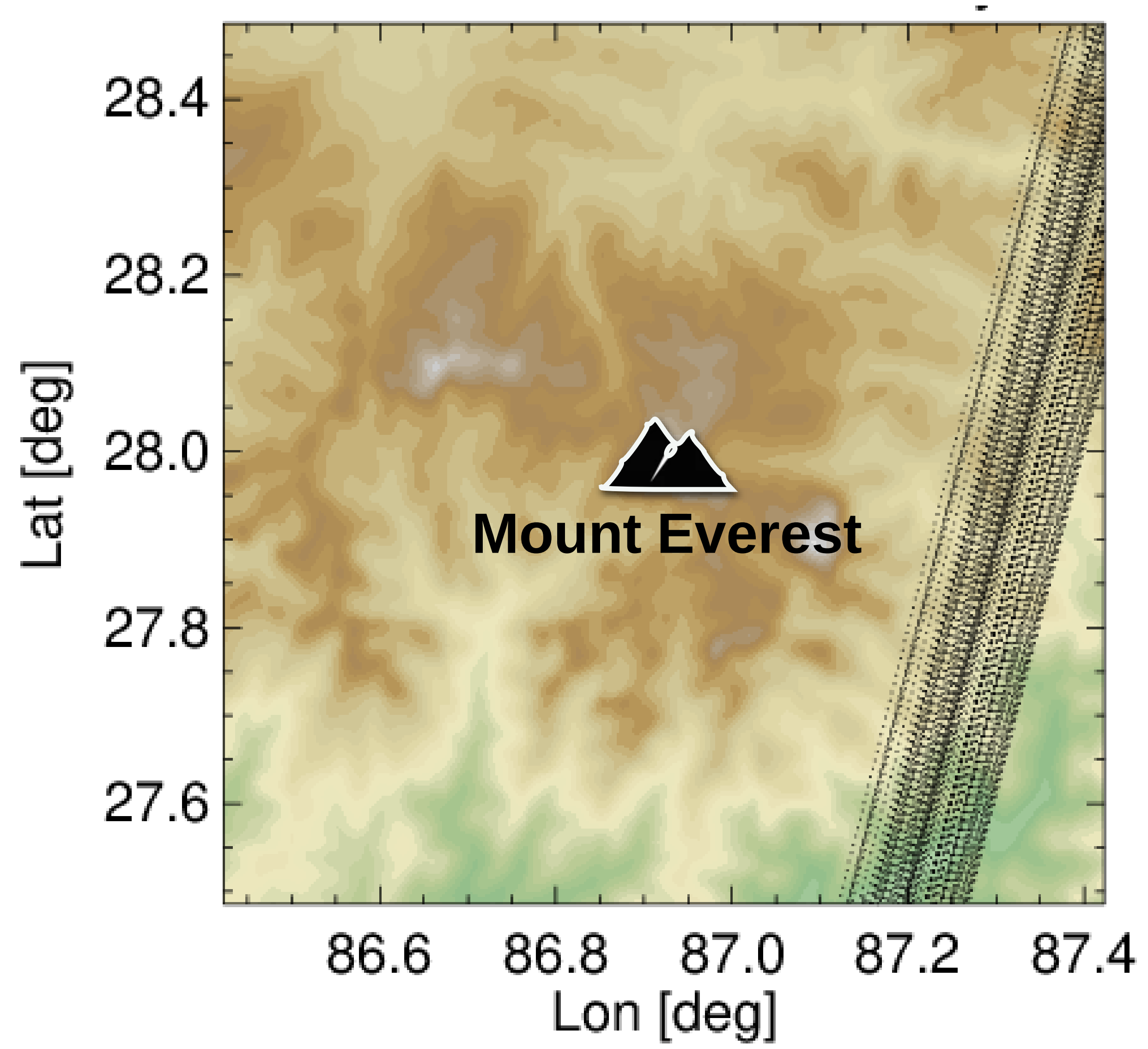
Comparing the CPR and ATLID surface detection height to the reference DEM convoluted with the instrument's footprint

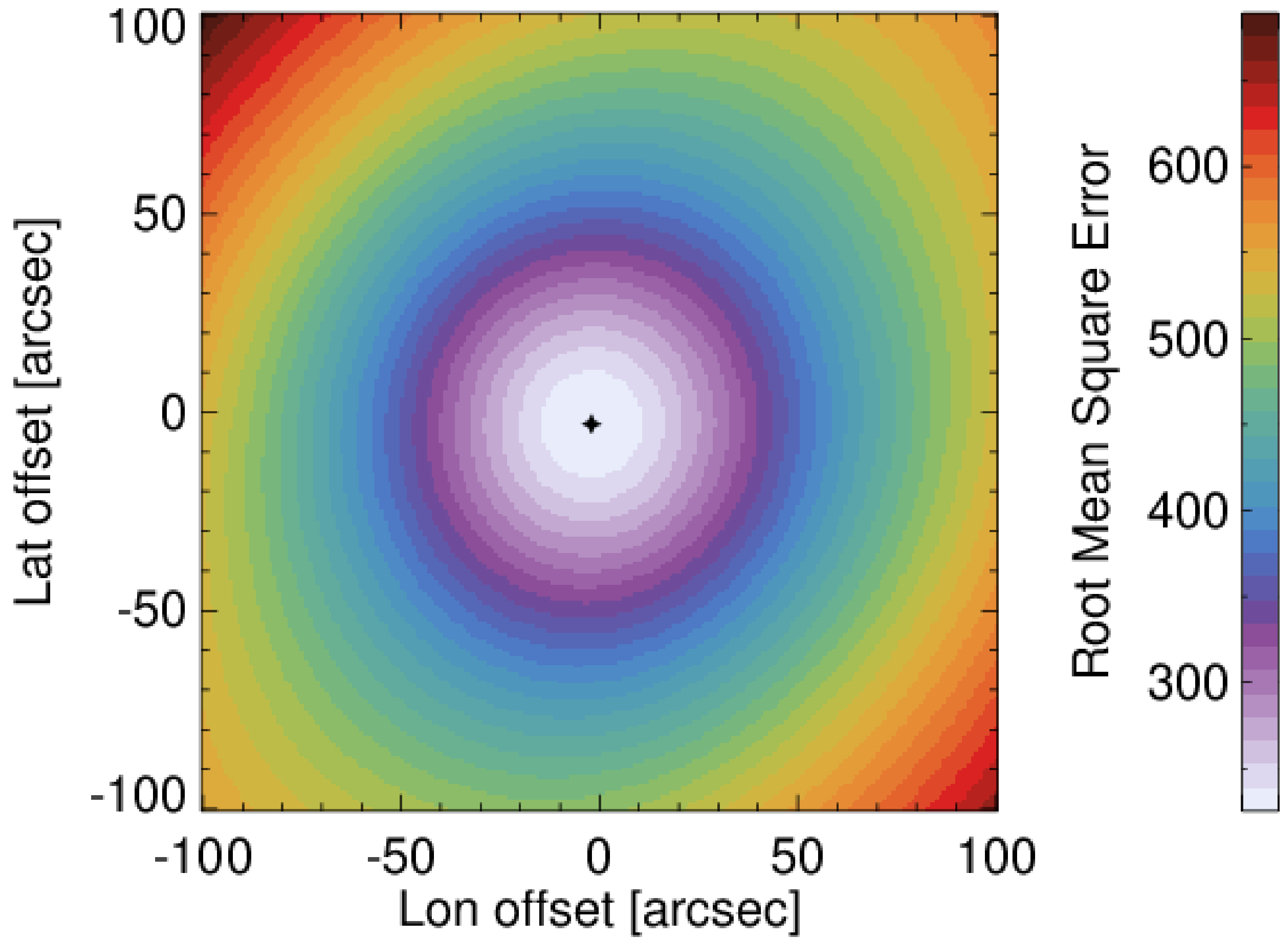


Artificial pointing errors are deliberately introduced in the along- and cross-track directions and the final geolocation error is found by minimizing the RMS error

CloudSat

Over the Himalayas





Eclipse (S-W)
86 orbits
Cross-track offset: -0.003º ~ -41m
Along-track offset: -0.008º ~ -102m

Antenna Pointing Characterization

Exploiting the CPR Doppler capability

Spaceborne Doppler Radar Measurements of Rainfall: Correction of Errors Induced by Pointing Uncertainties

Simone Tanelli, Eastwood Im, and Satoru Kobayashi

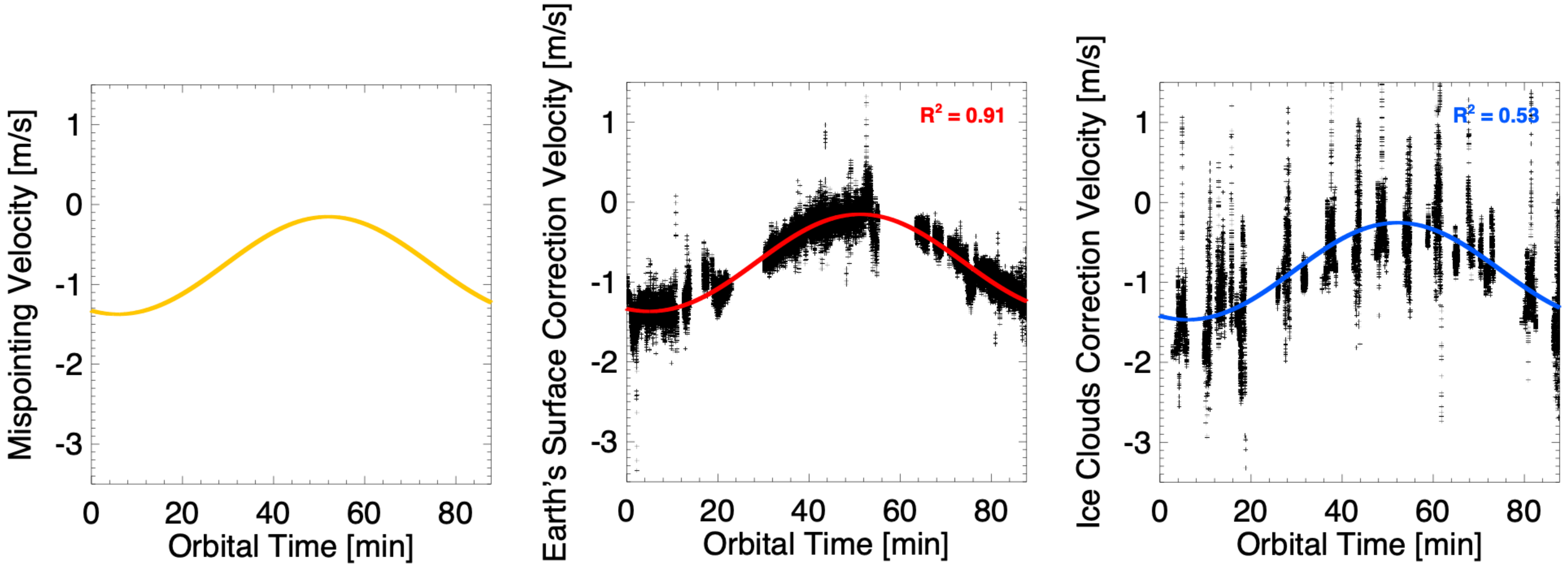
Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California

Roberto Mascelloni and Luca Facheris

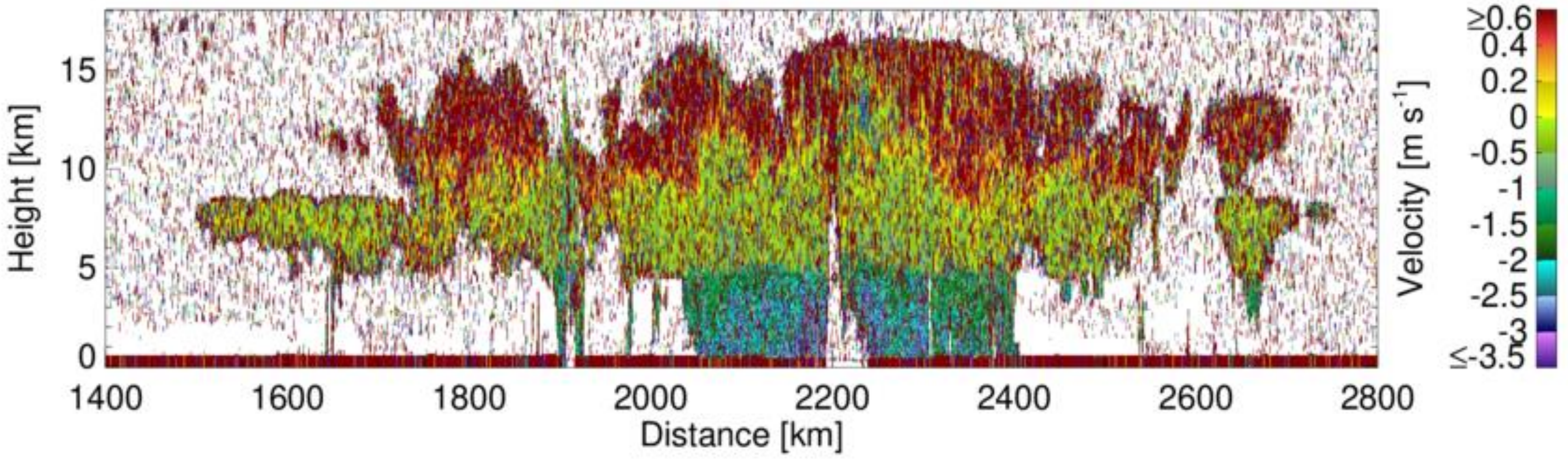
Dipartimento Elettronica e Telecomunicazioni, Università di Firenze, Firenze, Italy

Using Ice Clouds for Mitigating the EarthCARE Doppler Radar Mispointing

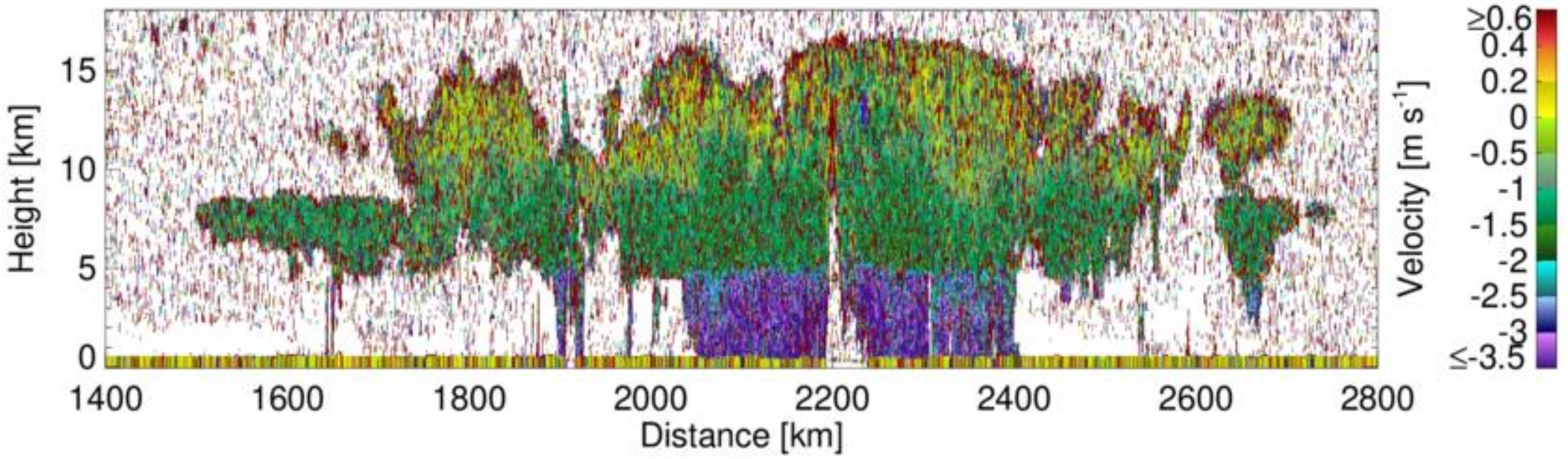
Alessandro Battaglia, *Member, IEEE*, and Pavlos Kollias



EarthCARE CPR Doppler velocity
with antenna mispointing

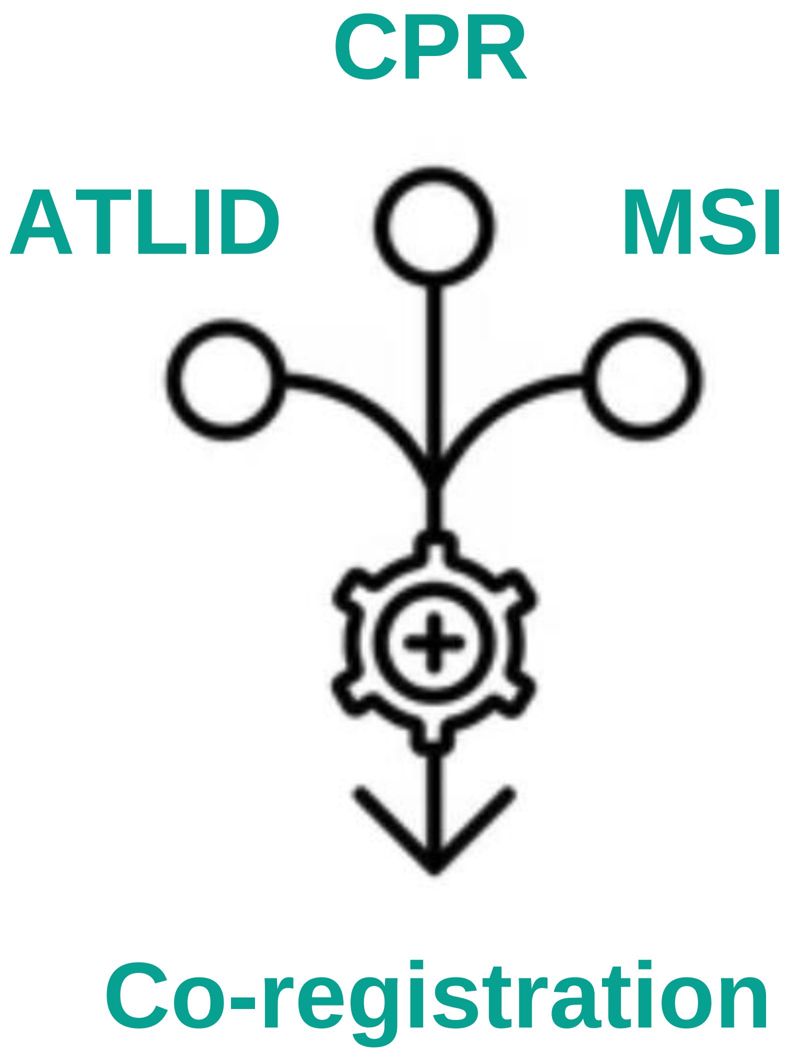


EarthCARE CPR Doppler velocity
after mispointing correction



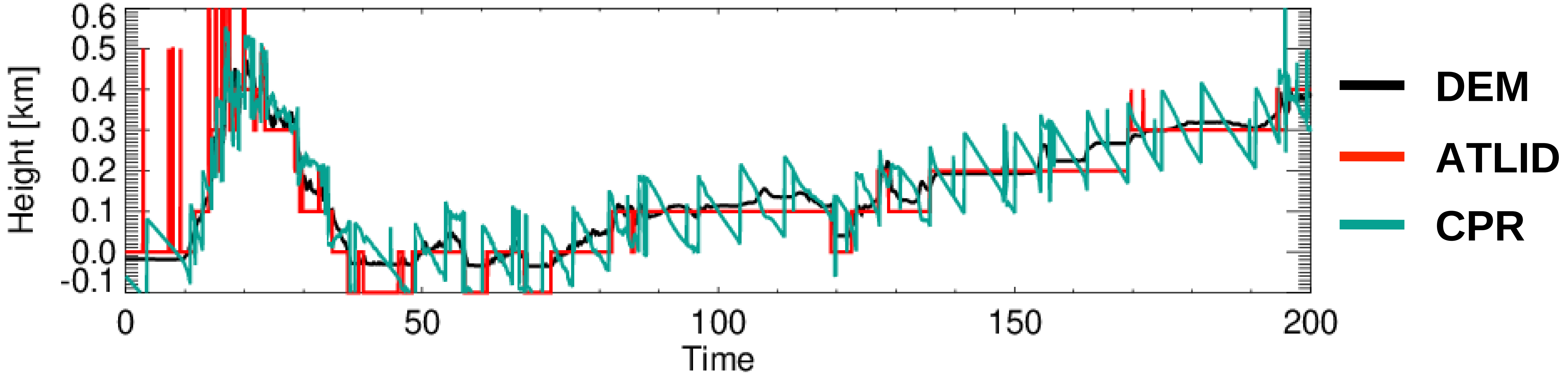
Co-registration

The individual geolocation analyses for each instrument will be combined to assess potential mis-registration. The analysis will be extended to the passive instruments



1) **Combine** the individual geolocation statistics of each instrument
2) **Minimize** the distance between detections from each instruments
3) **Compare** the surface height detection of the active instruments

EarthCARE CPR and ATLID surface height detection



thank you