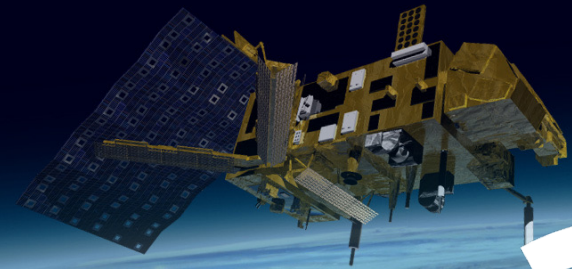


# The EO Processing Chain: Scatterometry As An Example

**Simon Kok Lupemba**

*Junior remote sensing scientist*

*JuliaEO24 11/01/2024*





# Agenda



- Introduction to EUMETSAT.
- The EO processing chain, scatterometry as an example.
- How we use Julia in my team.
- My personal view on Julia for EO processing.



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# An intergovernmental organisation with 30 member states

[www.eumetsat.int](http://www.eumetsat.int)





## Primary objective:

Establish, maintain and exploit European systems of meteorological satellites.

## Further objective:

Contribute to the operational monitoring of the climate and the detection of global climatic changes.





# European EO missions

www.eumetsat.int



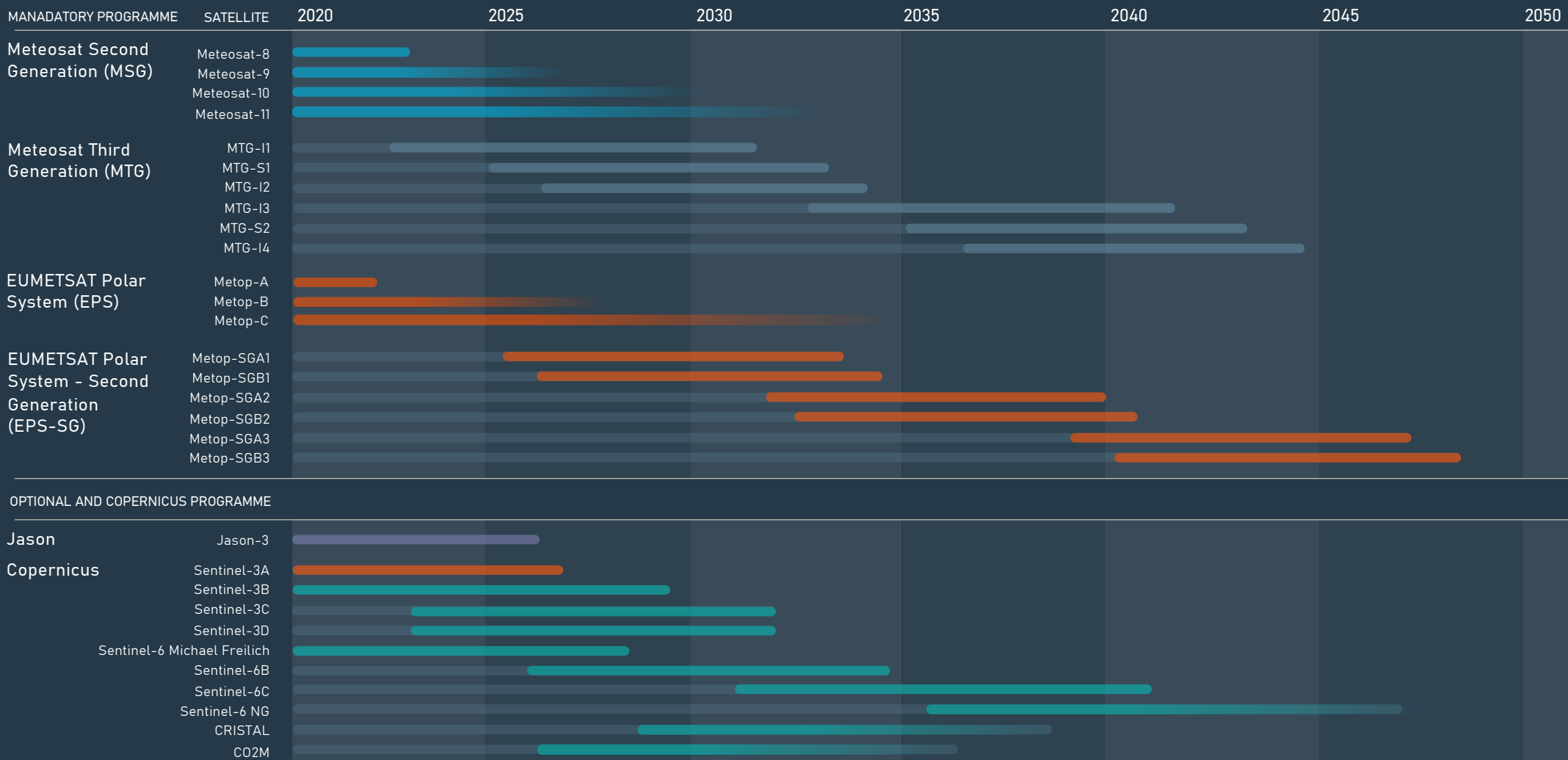
## ESA-DEVELOPED EARTH OBSERVATION MISSIONS





# EUMETSAT mission planning

www.eumetsat.int





# Agenda

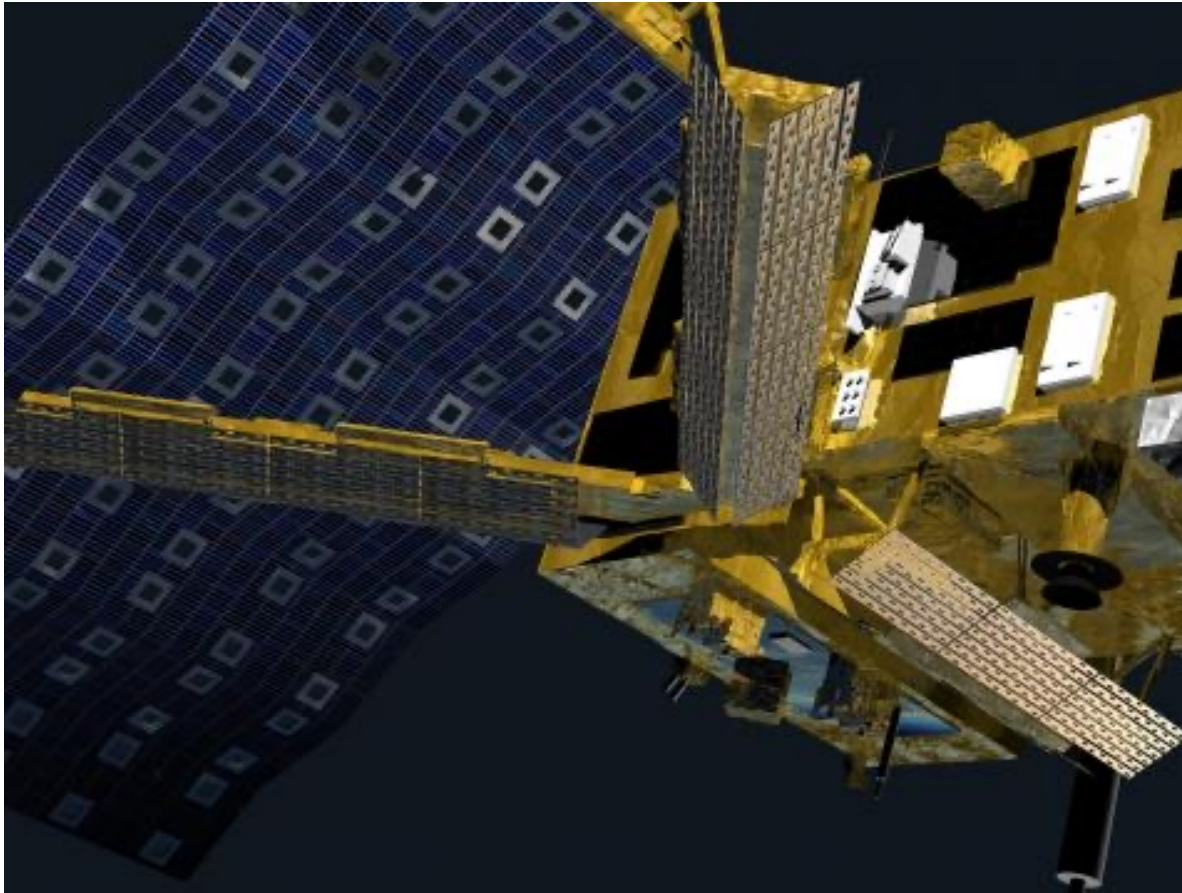
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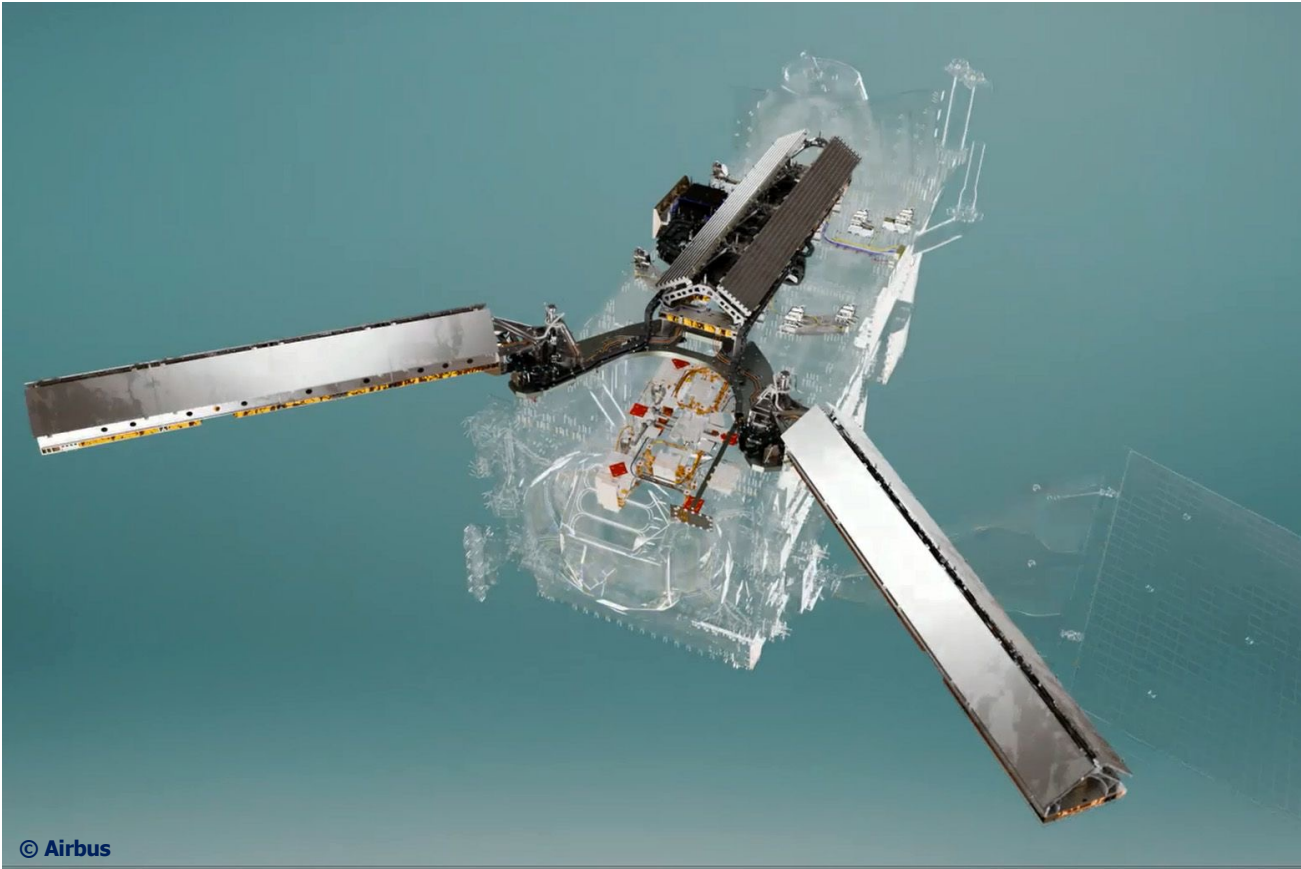
# Advanced SCATterometer (ASCAT) - METOP

[www.eumetsat.int](http://www.eumetsat.int)



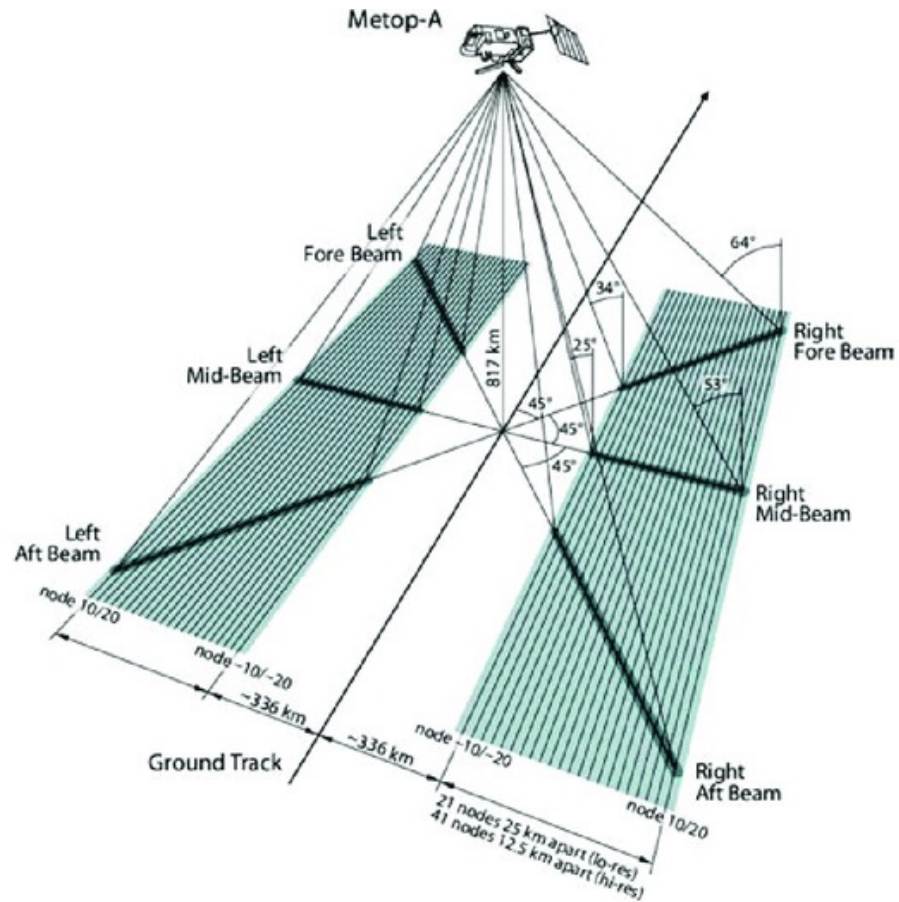
# Scatterometer (SCA) – METOP Second Generation

[www.eumetsat.int](http://www.eumetsat.int)





# Side looking radar





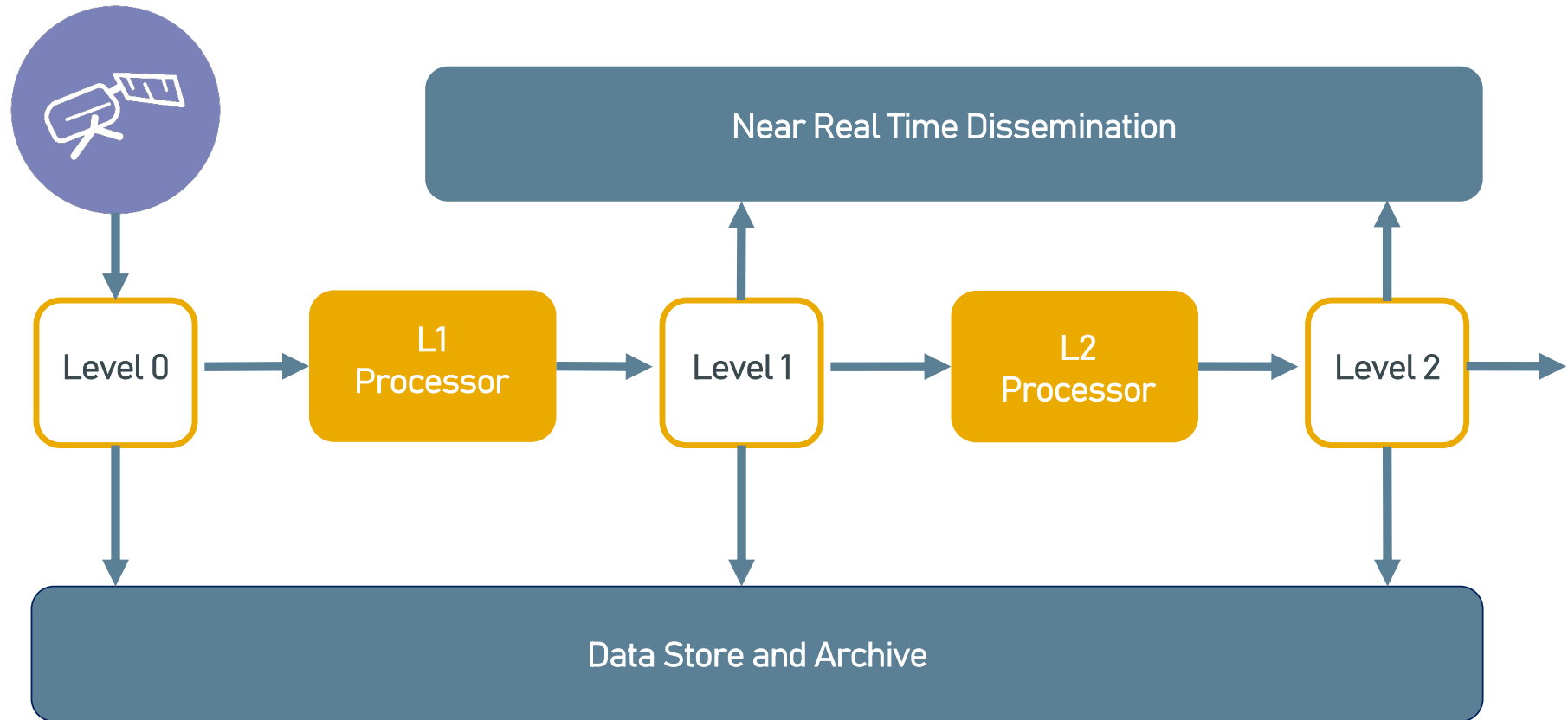
# Data Processing Levels

- Used by NASA, ESA, EUMETSAT and more.
- Level 0: Raw instrument data
- Level 1: Radiometrically and geometrically calibrated geo-located data.
- Level 2: Derived geophysical variables.



# Overview of processing chain

www.eumetsat.int





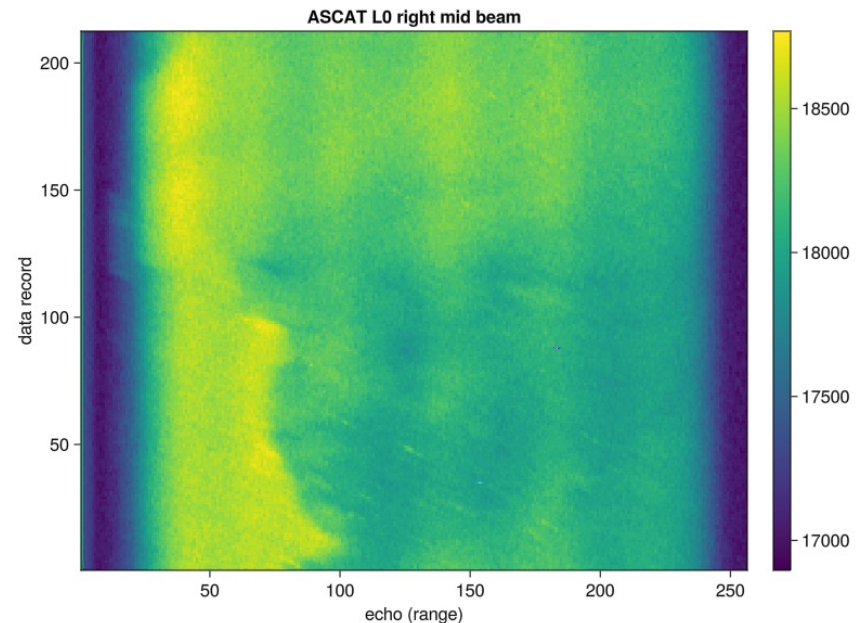


## Level 0 – Instrument data

- Comes in data records.
- Contains antenna id, echo, noise measurements, internal temperatures and more.
- Only dimension is time from the internal clock
- Everything is in unsigned integers. No units
- Data rate.
  - ASCAT ~5 kB/s, ~20 MB/h (On board averaging)
  - SCA ~ 1.2 MB/s, ~ 4.25 GB/h (No on-board averaging)

```
www.eumetsat.int
julia> Int.(record_example.source_packet.echo)
256-element Vector{Int64}:
 17940
 17266
  ⋮
 17052

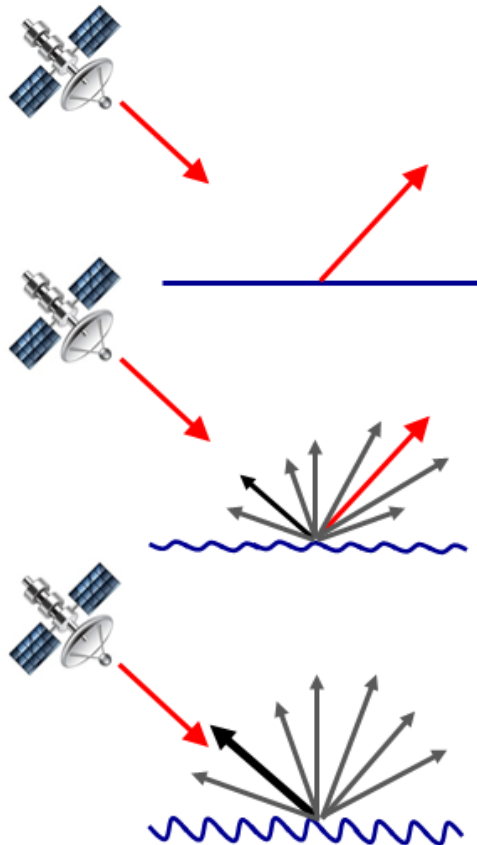
julia> Int.(record_example.source_packet.ant_temperatures)
12-element Vector{Int64}:
 939
 734
  ⋮
 694
```







# Level 1 – Geolocated backscatter



## No wind

Sea surface is flat

Most energy is reflected away from the sensor

## Light wind

Sea surface roughens

Some energy is backscattered to sensor

## Strong wind

Sea surface roughness increases

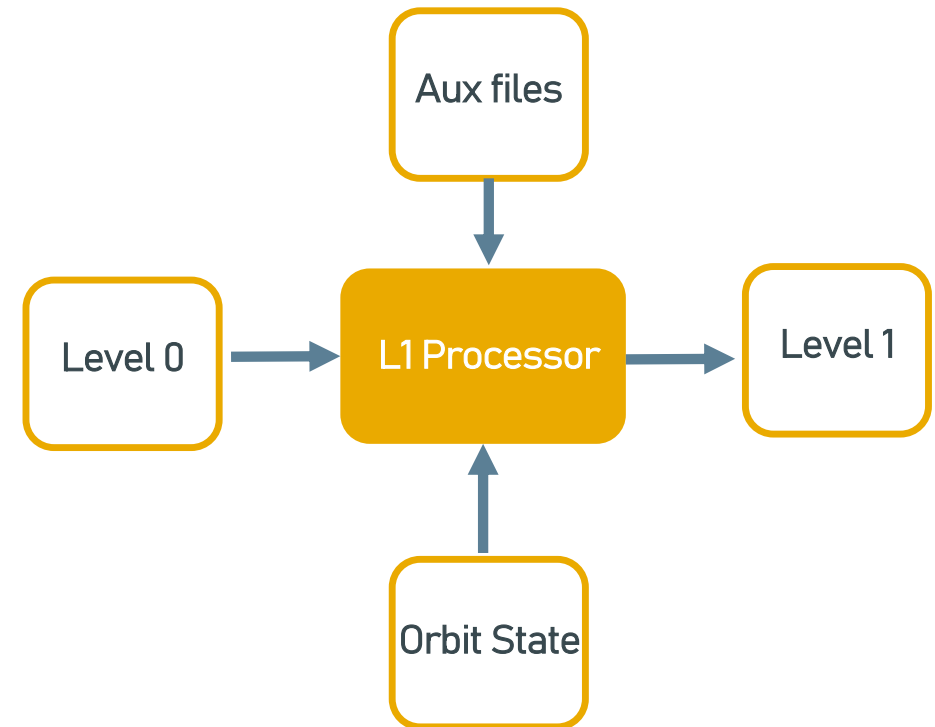
More energy is backscattered toward sensor

Credit: <https://coastwatch.gitbook.io/satellite-course/lectures/ocean-surface-winds>



# Level 1 processing

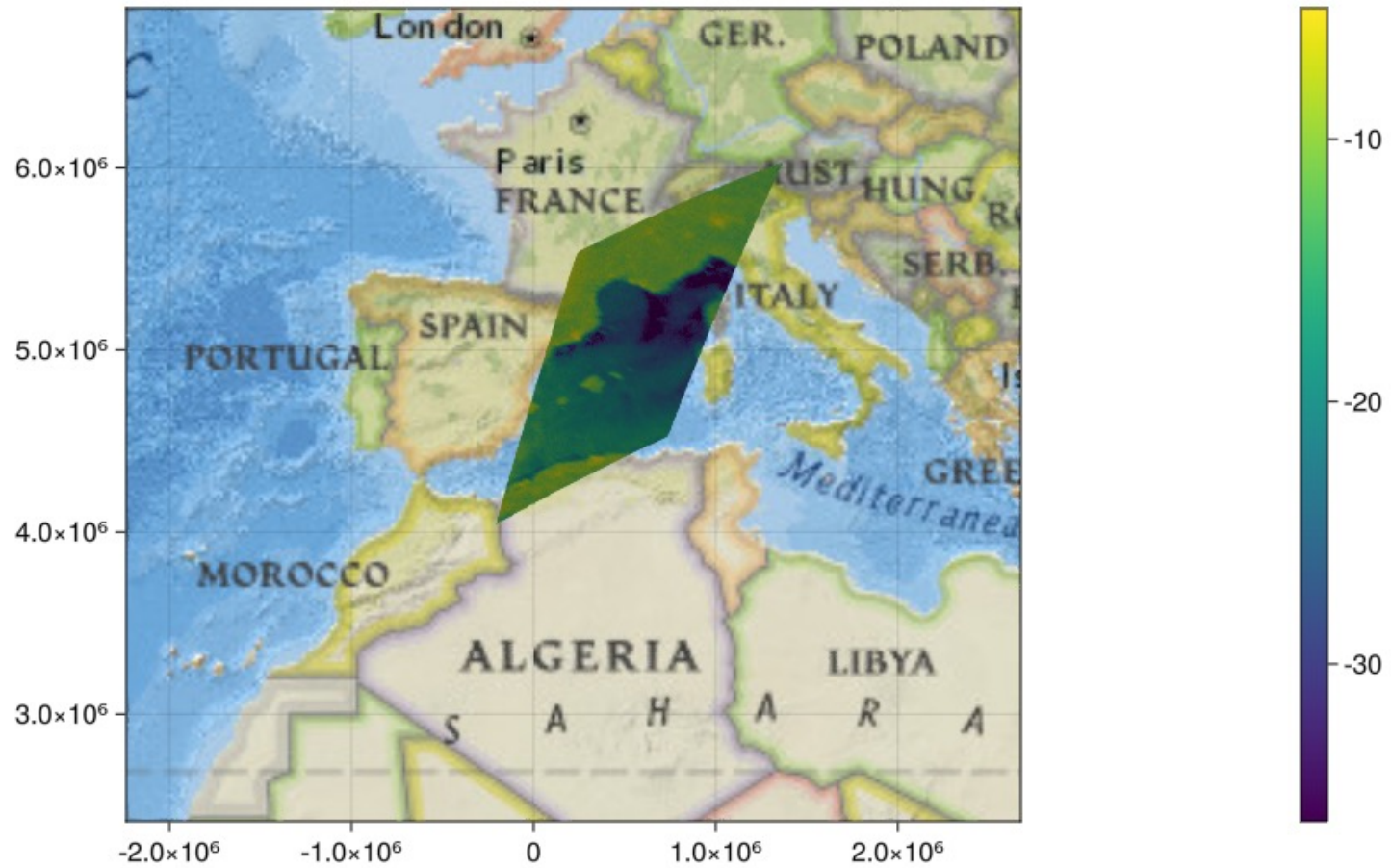
- Geolocate using orbit state and data record timestamps (leap seconds matter).
- Use Aux files to convert echo to Radiometrically calibrated backscattering coefficients.
- Add quality flags.
- Compute resampled products.



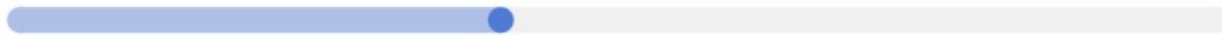


# SZF Makie demo

www.eumetsat.int



Antenna

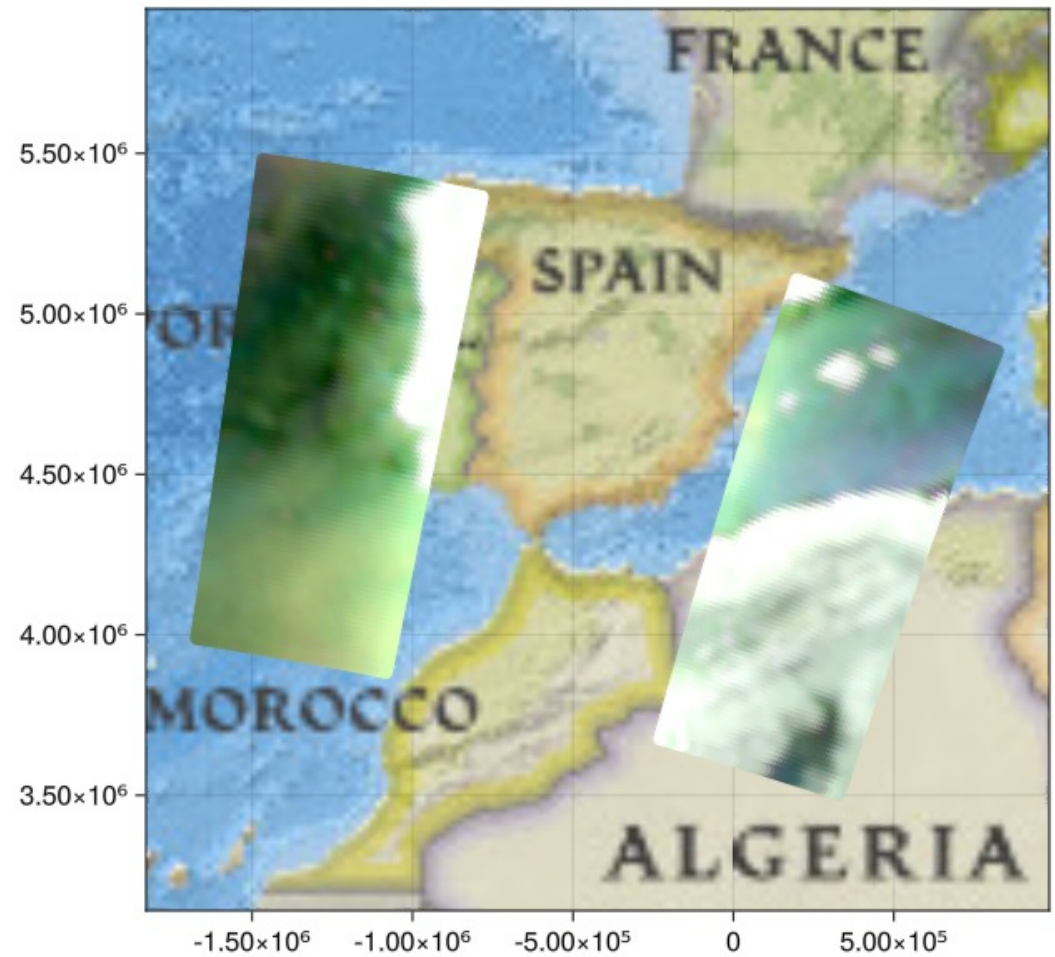


3



# SZR Makie demo

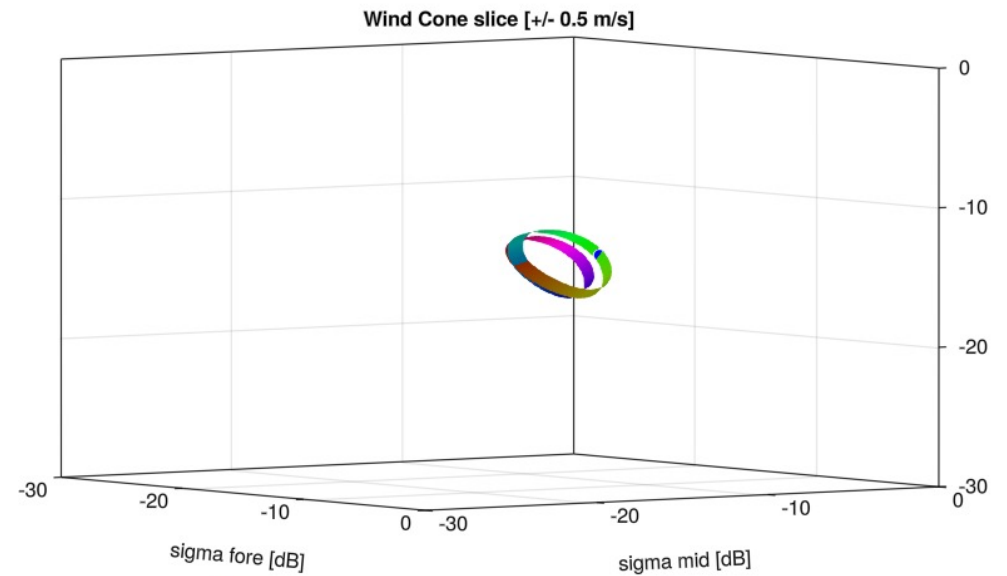
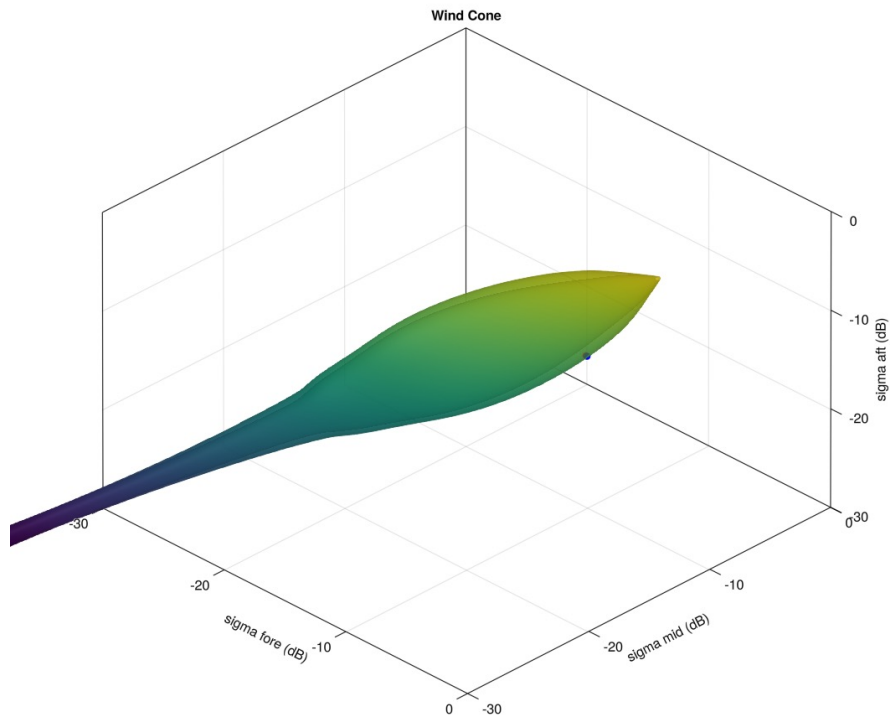
- $(R, G, B) = (\sigma_{for}, \sigma_{mid}, \sigma_{aft})$
- Scaled from -36 dB to -10 dB





# Level 2 – Winds Geophysical model (KNMI)

$$\sigma_0 = gmf(V, \phi_{rel}, \theta)$$





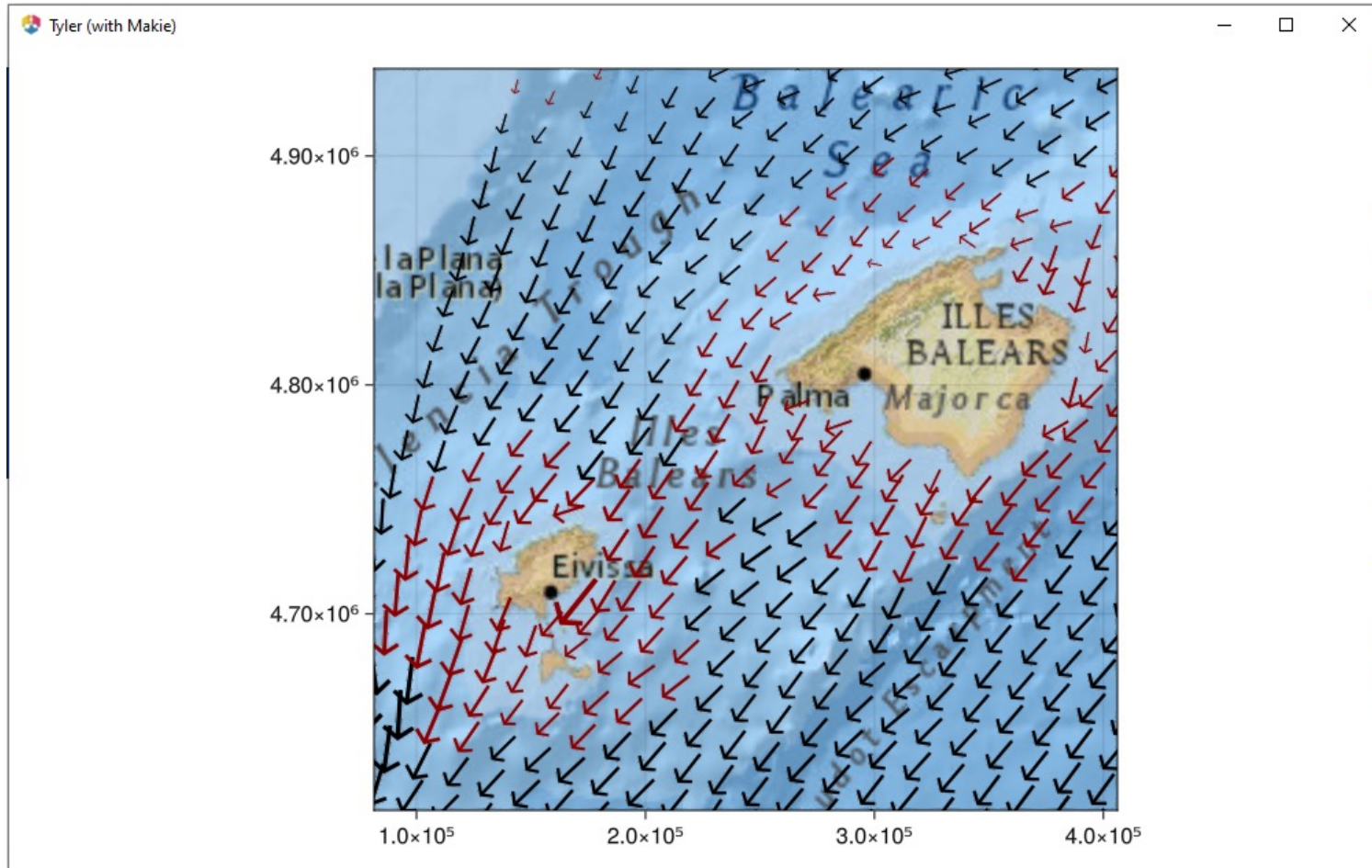
## Level 2 – Processing Wind

- Done by OSI-SAF.
- Estimate wind speed and direction based on level 1 backscatter.
- Only over ocean.
- Ambiguities corrections.
- Distance to model function.
- Quality flag.



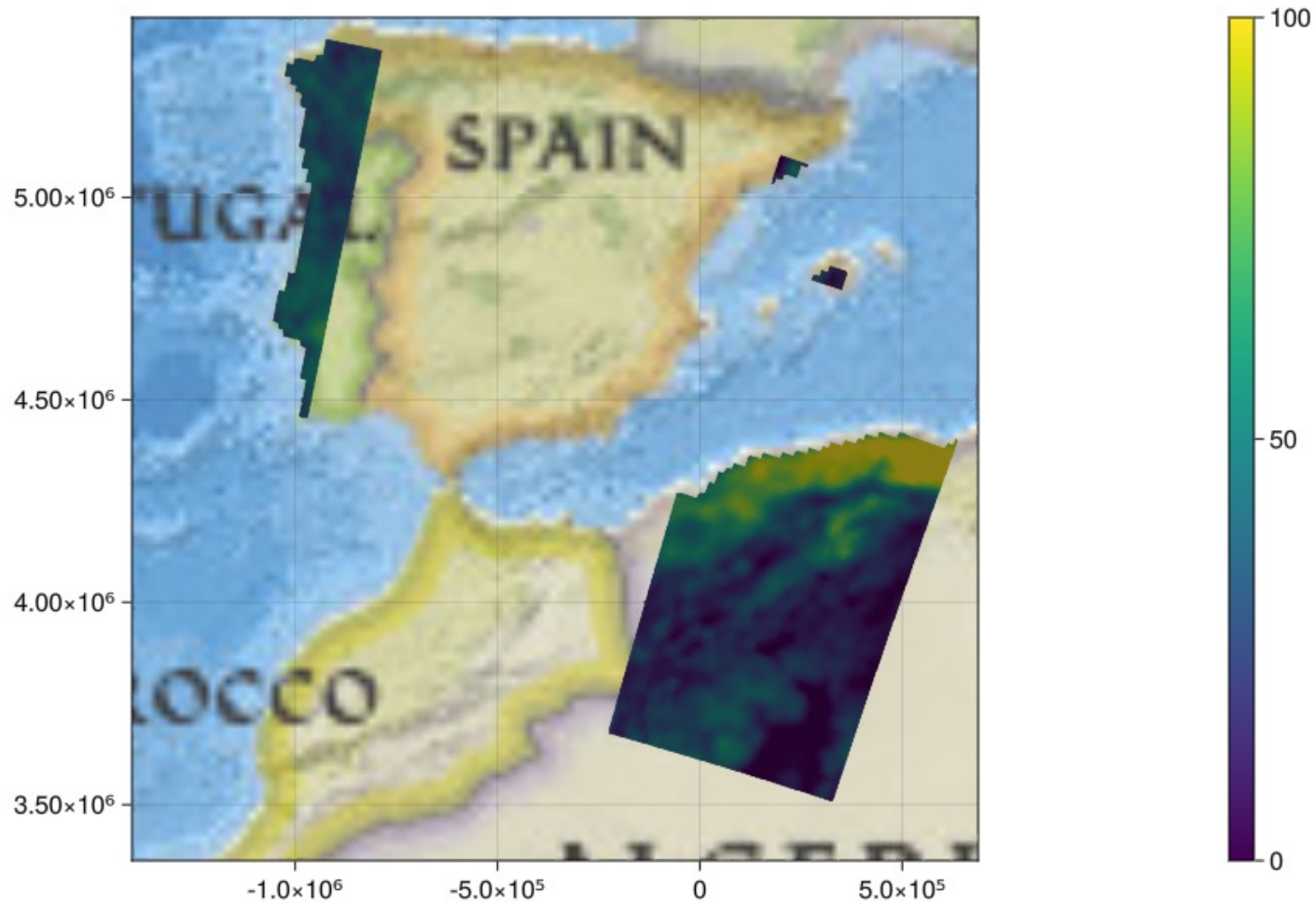


# Winds Makie demo





# Soil moisture Makie demo





# Beyond level 2

- Not my area of expertise.
- Fusion products.
- Interpolations.
- More complex products.

Home / Products / Global Sea Ice Edge

## Global Sea Ice Edge

NEAR REAL TIME PRODUCT

Operational

Ice classes are assigned from atmospherically corrected SSMIS and AMSR-2 brightness temperatures and ASCAT backscatter values, using a Bayesian approach. Both the sea ice edge product and the sea ice type product are classification products differing between different ice classes. Sea ice edge differs between the classes open water, open ice, and closed ice which are defined from the ice concentration thresholds of 30 % and 70 %, respectively. The product series is operational since 2005.

### Information

- Description →
- Quicklook →
- Quality →
- Production status →

### Identification

Acronym :	GBL SIED	Digital object identifier (DOI) :	<a href="https://doi.org/10.15770/EUM_SAF_OSI_NRT_20_05">10.15770/EUM_SAF_OSI_NRT_20_05</a>
Product navigator reference :	<a href="#">EO:EUM:DAT:MULT:OSIEDGBN</a>	Acronym for EDC (APNM) :	OSIEDGBN
OSI SAF producer :	Norwegian Meteorological Institute	Citation :	<a href="#">See at bottom</a>
Identifier :	OSI-402-d		

### Characteristics



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# What is Julia used for at EUMETSAT

- Julia is a niche at EUMETSAT
  - Visualisation
  - Monitoring of science data
  - Tools for calibration
  - Regression testing
  - Prototyping
- 
- Julia is not used in the operational processing chain



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# My personal view on Julia for EO processing.

[www.eumetsat.int](http://www.eumetsat.int)

- Opportunities
  - High performance scientific computing.
  - Composability via package could improve reusability.
  - More open source.
  - Flexible data types.
  - Potential in the whole chain. From L0 processing to large weather models.
- Challenges
  - EUMETSATS is not a first mover (Long operational programs).
  - Awareness.
  - Industry uptake.
  - Maturity.
  - Open source vs proprietary information.



# My personal view on Julia for EO processing.

[www.eumetsat.int](http://www.eumetsat.int)

- The road forward.
  - I hope to publish `AscatData.jl`.
  - Contribute to open source packages relevant for EUMETSAT.
  - Prove the value of Julia through non-operational tools.
  - Keep an eye out for first movers.
  - Advocate for Julia at EUMETSAT.



- Use the data.  
<https://data.eumetsat.int/>
- EUMETSAT Meteorological Satellite Conference 2024
- I hope to see Julia users at the conference.
- Early Career Scientists Initiative (Under 32 and under 2 years work experience)



**Thank you!**  
Questions are welcome.