Low-frequency passive microwave observations for an all weather and high spatial resolution characterization of the ocean surface and sea ice

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Low frequency passive microwave observations below 12 GHz over ocean can provide:

Sea Surface Temperature (SST)
Sea Ice Concentration (SIC)
Sea Surface Salinity (SSS)
Ocean Wind Speed (OWS), even for very high wind speeds
Sea Ice Thickness (SIT) below 1m

… In addition to land applications with parameters such as soil moisture, surface water extent, vegetation information…

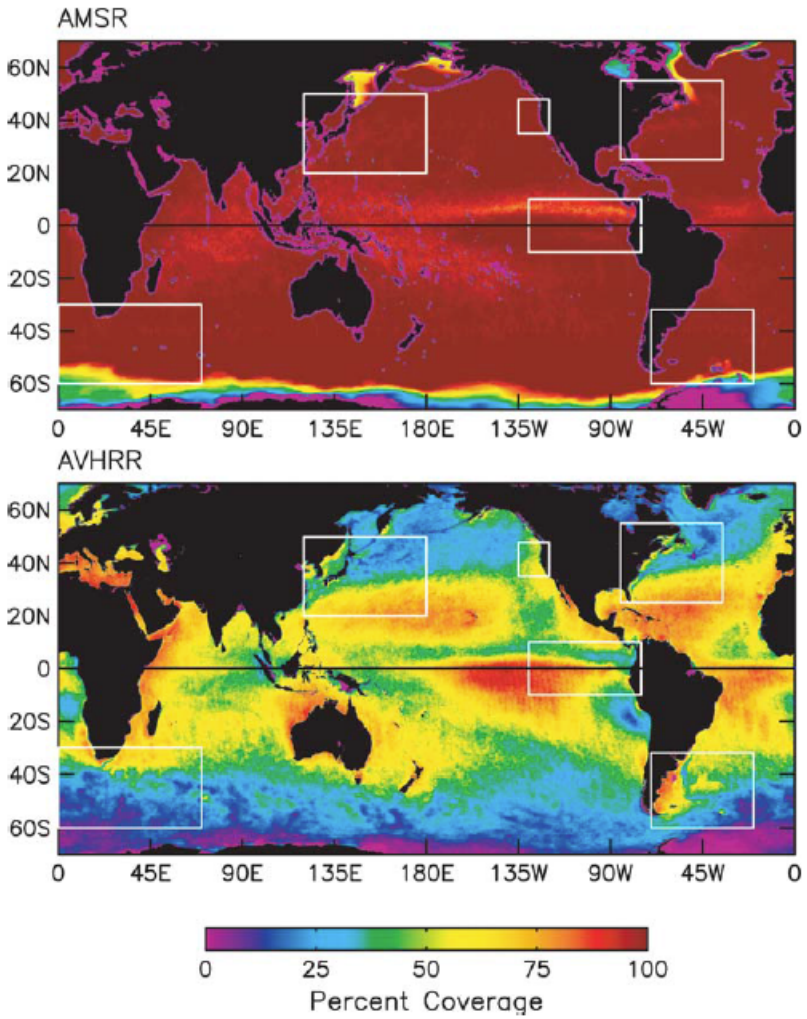
Passive microwave observations above 12 GHz very well covered in the future by the MetOp-SG instruments

- MicroWave Imager (MWI) from 18 to 190 GHz
- MicroWave Sounder (MWS) from 23 to 230 GHz
- Ice Cloud Imager (ICI) from 170 to 664 GHz

But below 12 GHz, very uncertain future

- AMSR continuity?
- SMOS / SMAP continuity?

Sea Surface Temperature (SST)



From Chelton et al. 2005

Current situation

- SST derived from IR under clear sky (<40%)
- SST derived from microwave sensors under cloudy condition and at night (e.g., AMSR)

Limitations

- The microwave frequency the most sensitive to the full range of SST is around 6 GHz, but it is only available at low spatial resolution so far (~ 50 km at 6 GHz) and with limited accuracy
- No guarantee of measurement continuation

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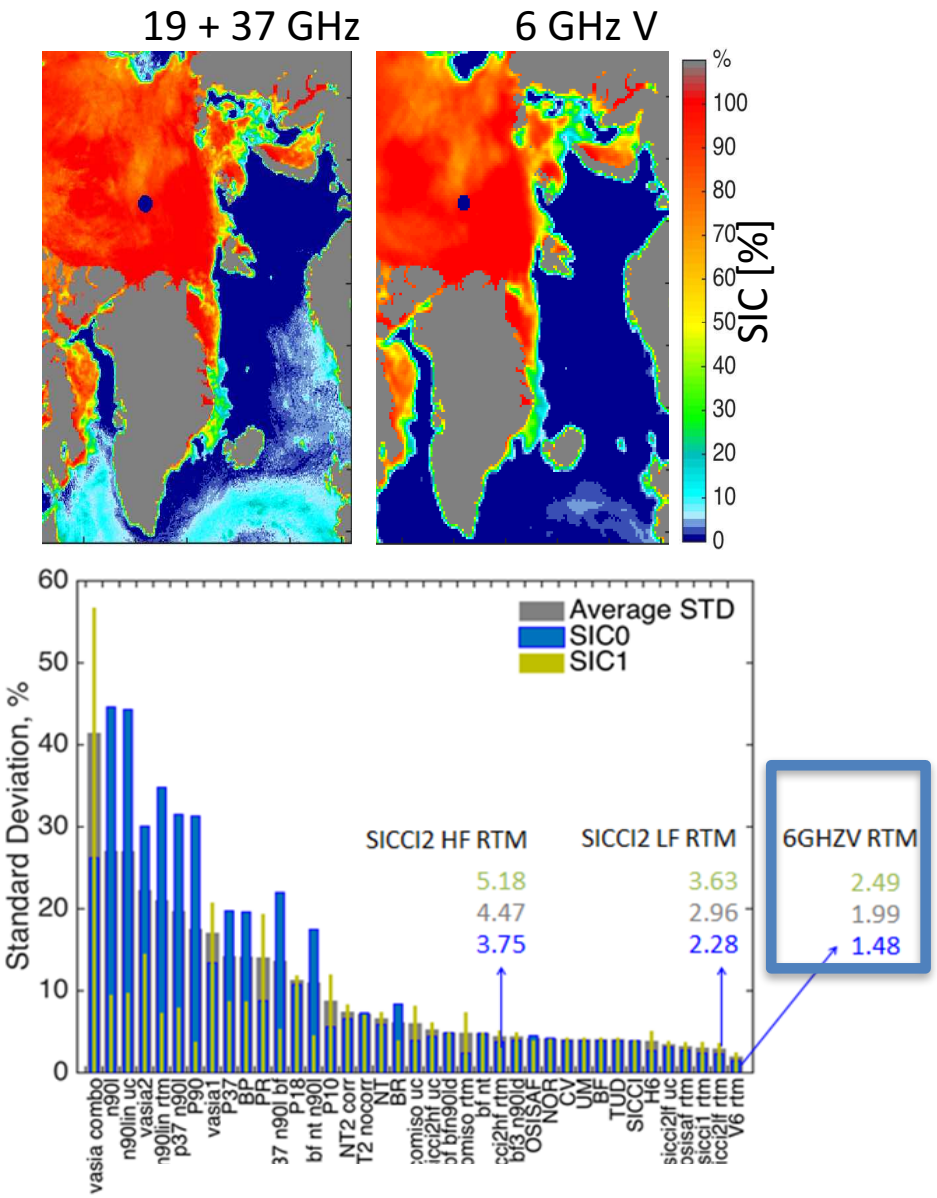
Sea Ice Concentration (SIC)



Figures courtesy Sea Ice CCI team

Current situation

- SIC derived from VIS under clear sky and daylight
- SIC derived from microwave sensors under cloudy condition and at night (e.g., AMSR)

Limitations

- The 6 GHz is the most sensitive frequency to SIC, but is only available at low spatial resolution so far (~ 50 km using 6 GHz)
- No guarantee of measurement continuation

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The idea

- To develop an instrument that can provide **simultaneously and consistently** the ocean parameters (SST, SIC, SSS, OWS, SIT)
    - with **good spatial resolution**
    - with **improved accuracy**

Optimization of the observation conditions

(frequency, incidence angle, polarization)

- Using information content analysis
- Taking into account the technological constraints

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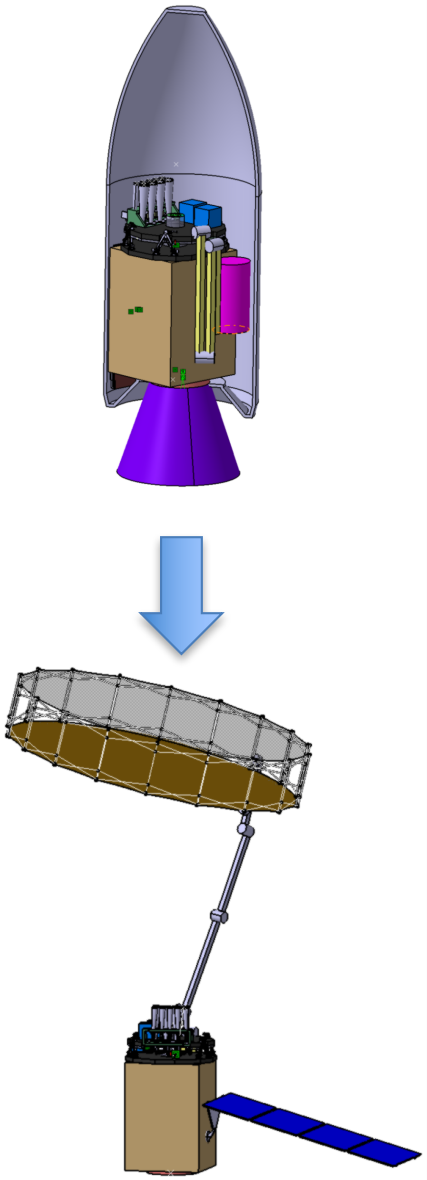
The instrument concept

- Passive microwave conically scanning imager (44°)
- 3 channels with full polar receivers and RFI mitigation
- Very low noise receivers

Frequency (GHz)	1.4	6.9	10.65
Footprint (km)	59	15	12
NeDT (K)	0.14	0.12	0.18

- 5 m mesh Large Deployable Reflector rotating at 7 RPM
- Polar orbit (close to MetOp-SG B ?)



- Mesh reflector: European ESA studies, US flight model (SMAP)
  (5m so far for the calculation but possibility up to 7m)
- Scan mechanism and RFI: MetOp-SG MWI heritage

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The instrument concept

Frequency (GHz)	Bandwidth (MHz)	Polarization	NeDT (K)	Application	Footprint size at 3dB
1.4	27	V, H, S3, S4	0.14	-Sea Surface Salinity -High Ocean Wind Speed -Thin Sea Ice Thickness	59
6.9	200	V, H, S3, S4	0.12	-Sea Surface Temperature -Sea Ice Concentration	15
10.65	100	V, H, S3, S4	0.18	- Ocean Wind Speed	12

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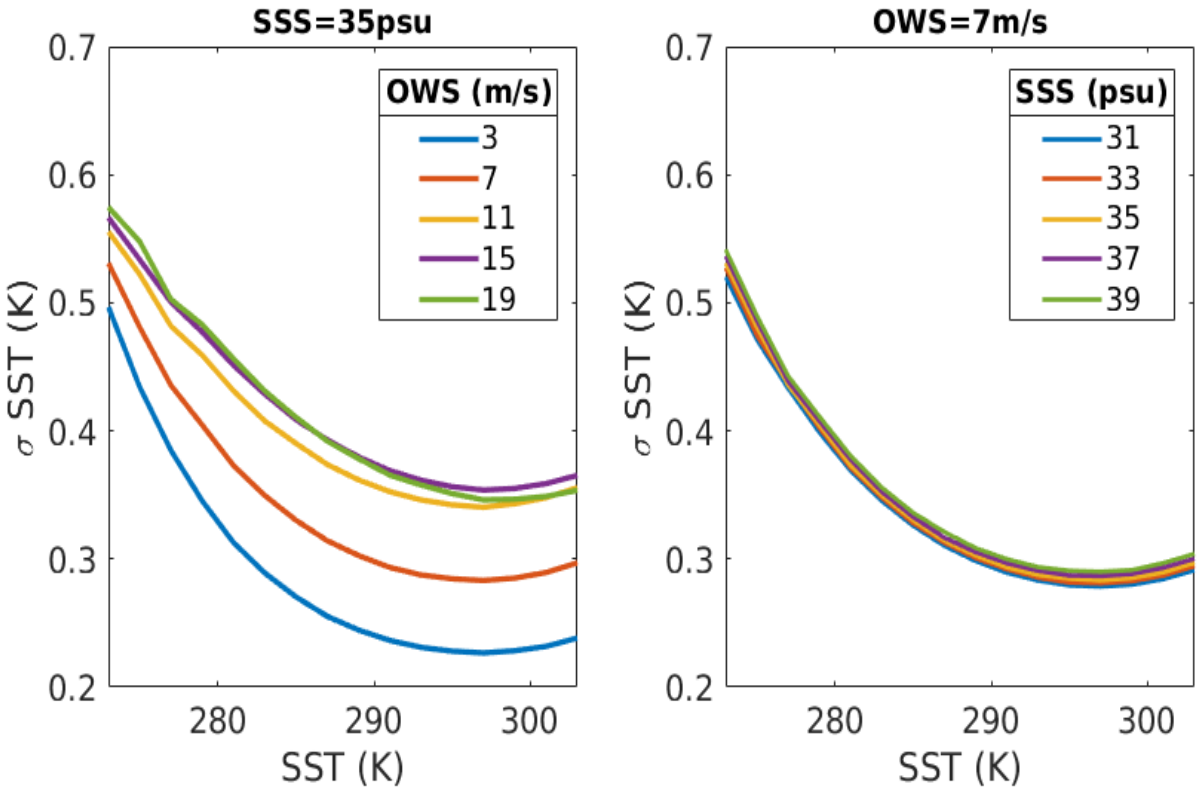
Ice-Free Sea Surface Parameter Retrieval

Sea Surface Temperature

- High retrieval accuracy (0.3K)
  (estimated theoretically from information content analysis built upon up-to-date radiative transfer and realistic hypothesis)



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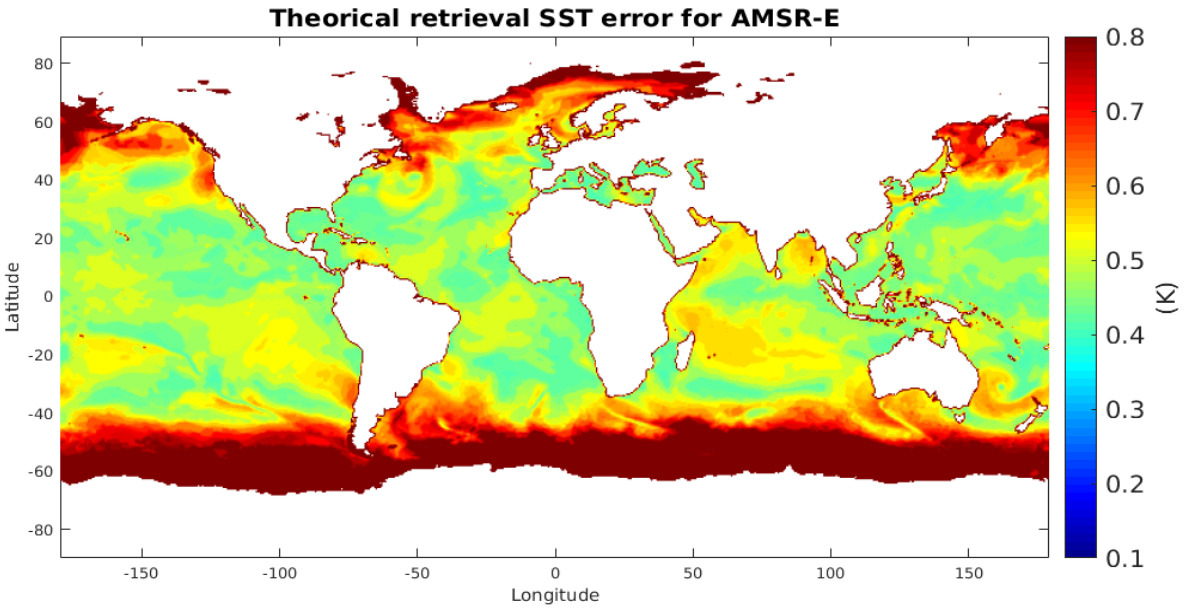
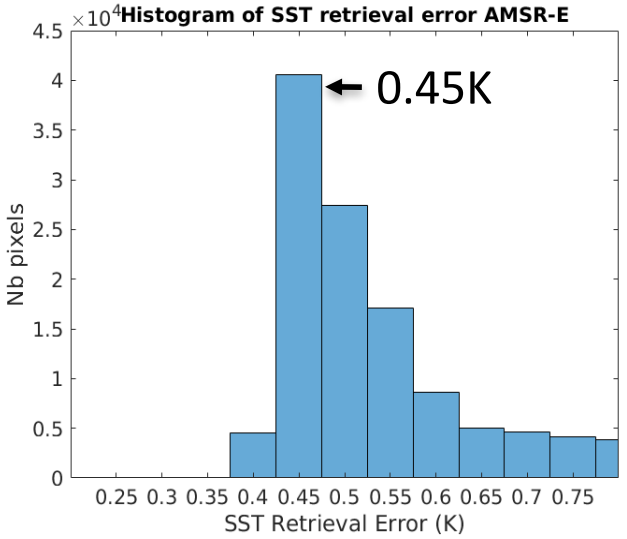
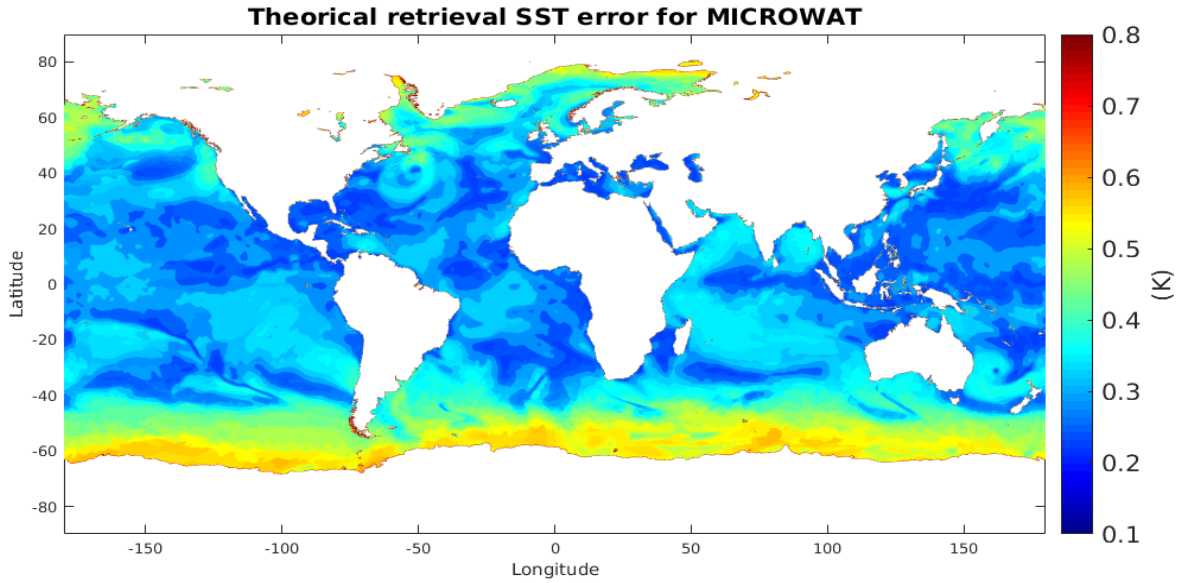
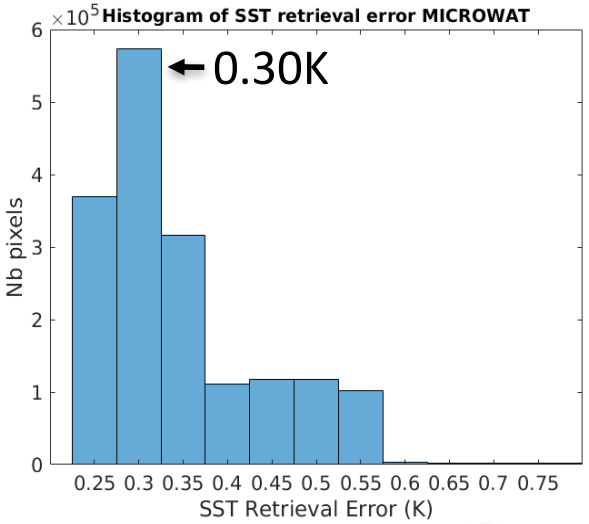
Ice-Free Sea Surface Parameter Retrieval









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Ice-Free Sea Surface Parameter Retrieval

Sea Surface Temperature

- High retrieval accuracy (0.3 K)
- Better spatial resolution (15 km instead of 50 km)
- Better cover of coastal areas (down to 20 km)

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Ice-Free Sea Surface Parameter Retrieval

Original SST

Retrieval errors

AMSR

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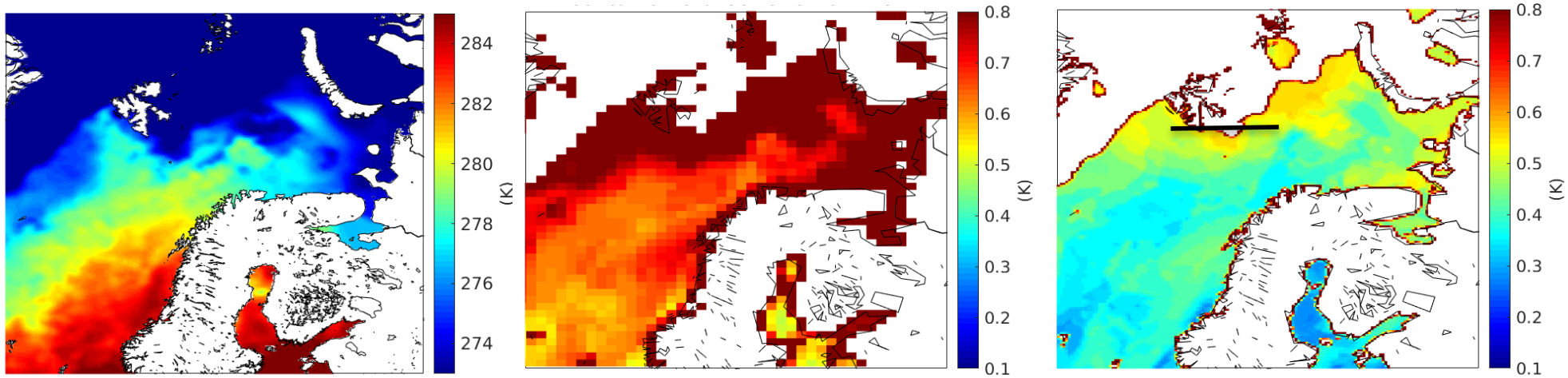
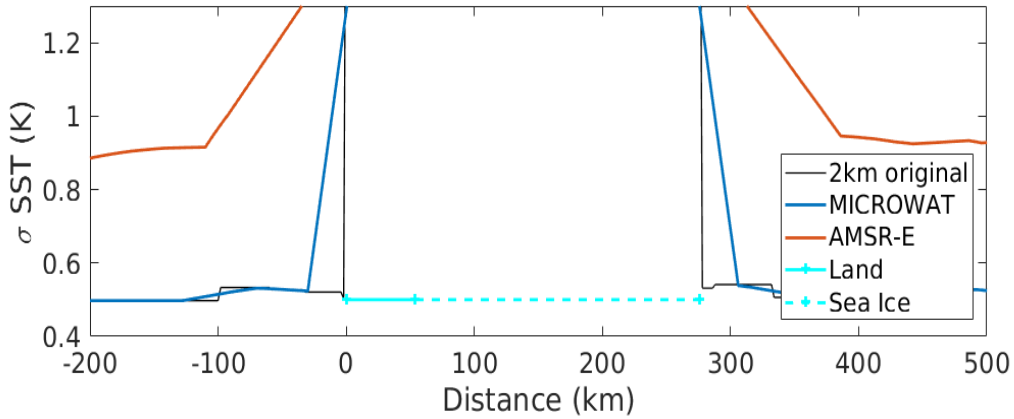


Improvement close to the coasts and sea ice margins



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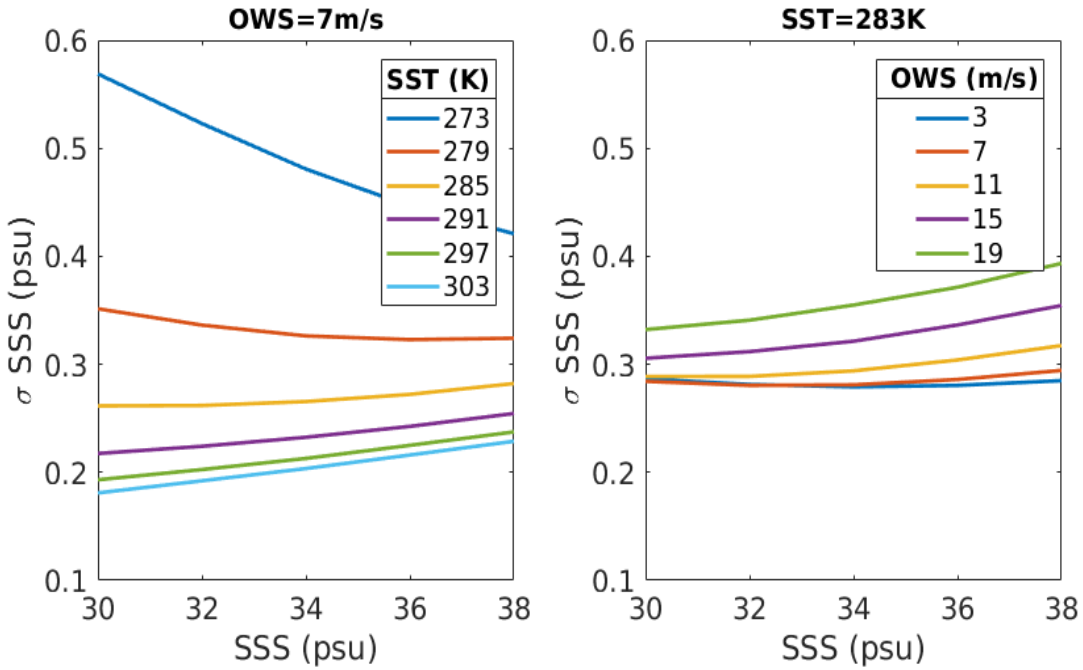
Ice-Free Sea Surface Parameter Retrieval

Sea Surface Temperature

- High retrieval accuracy (0.3 K)
- Better spatial resolution (15 km)
- Better cover of coastal areas (down to 20 km)

Sea Surface Salinity

- High radiometric sensitivity to provide a theoretical accuracy of 0.5 psu instantaneously
- Coincident and consistent analysis of the SST and SSS



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Ice-Free Sea Surface Parameter Retrieval

Sea Surface Temperature

- High retrieval accuracy (0.3 K)
- Better spatial resolution (15 km)
- Better cover of coastal areas (down to 20 km)

Sea Surface Salinity

- High radiometric sensitivity to provide an accuracy of 0.5 psu instantaneously
- Coincident and consistent analysis of the SST and SSS

High Sea Surface Wind Speed

- Estimation of the high surface wind speed with the 1.4 GHz.

Applications

- NWP assimilation and climate models
- Physical and biogeochemical air/sea interaction
- Study mesoscale variability, heat, and energy transport
- Understanding marine ecosystem variability

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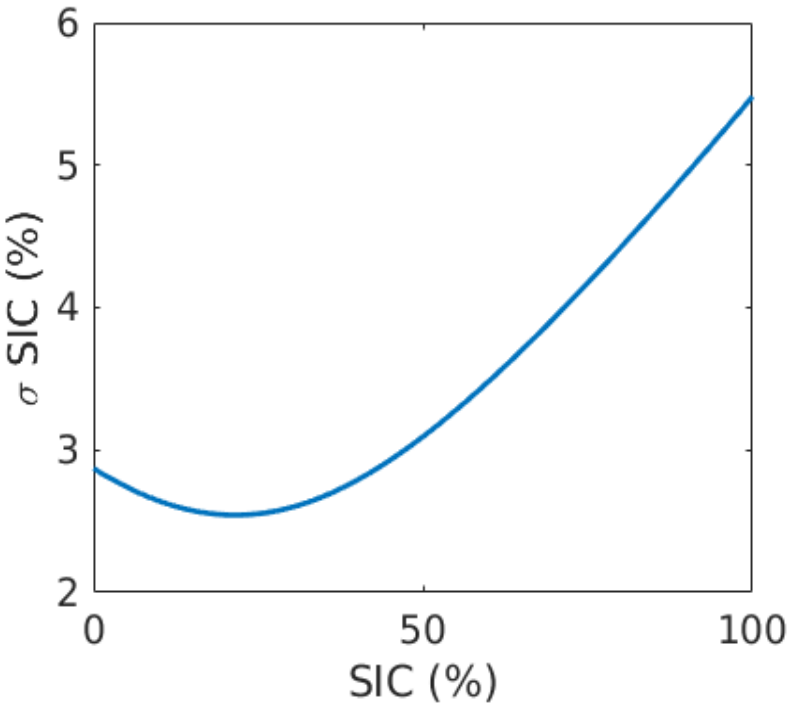
Sea Ice Parameter Retrieval

Sea Ice Concentration

- Accuracy of 5%
- Possibility to retrieve low SIC values



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Sea Ice Parameter Retrieval

Sea Ice Concentration

- Accuracy of 5%
- Possibility to retrieve low SIC values
- Better spatial resolution (15km)
- Possibility to analyse the ice margin

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Sea Ice Parameter Retrieval

Original SIC

Retrieval errors

AMSR

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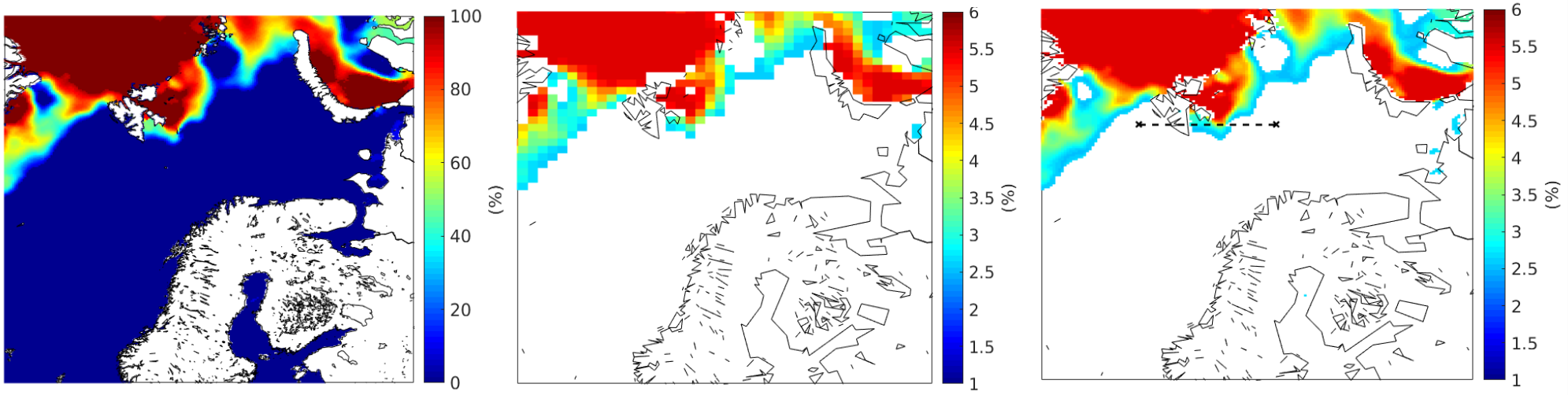

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Sea Ice Parameter Retrieval

Sea Ice Concentration

- Accuracy of 5%
- Possibility to retrieve low SIC values
- Better spatial resolution (15km)
- Possibility to analyse the ice margin
- Refinement of the retrieval under way to benefit from the low instrument noise

Thickness of thin sea ice

- Demonstrated with SMOS and SMAP

Applications

- NWP assimilation and climate models
- Ship and offshore operations
- Study mesoscale variability
- Physical and biogeochemical air/sea interaction

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Parameter Retrievals

	Product	Spatial resolution	Accuracy*	SRL
Ice-free ocean	Sea Surface Temperature (**SST**)	15 km	0.3 K	5
	Ocean Wind Speed (**OWS**) (< 20m/s)	15 km	0.5 m/s	5
	Very high Ocean Wind Speed (**OWS**) (>20m/s)	59 km	4 m/s	4
	Sea Surface Salinity (**SSS**)	59 km	0.5 psu	5
Sea ice	Sea Ice Concentration (**SIC**)	15 km	5 %	5
	Sea Ice Thickness (**SIT**) (< 1m)	59 km	10 cm	4

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Conclusion

- With simultaneous measurements in L, C, and X bands, estimates of key oceanic variables for meteorology, oceanography, and climate analysis, with unique synergies
- 'All weather' products, with better quality, higher spatial resolution (for most products) , and available close to the coasts
- With no guarantee of continuation of low frequency measurements (after AMSR2, SMOS, and SMAP), it will insure continuity, with improved products (for most products)
- Needless to say, it will also benefit the land surface community (soil moisture, surface waters, vegetation characterization…)

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