

The Aquarius Radiometers and Radio Frequency Interference: Analysis of RFI at L-Band and its Impact on Salinity Retrieval

Paolo de Matthaeis, Yan Soldo

GESTAR Goddard Space Flight Center, USA



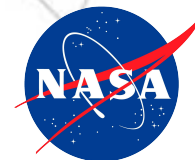
Jet Propulsion Laboratory
California Institute of Technology

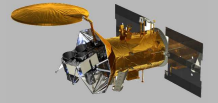
Seung-bum Kim

Jet Propulsion Laboratory, USA

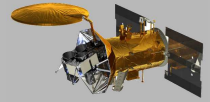
David M. Le Vine

NASA Goddard Space Flight Center, USA



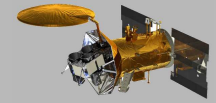


- Introduction
- Analysis of RFI environment changes
- Conclusions

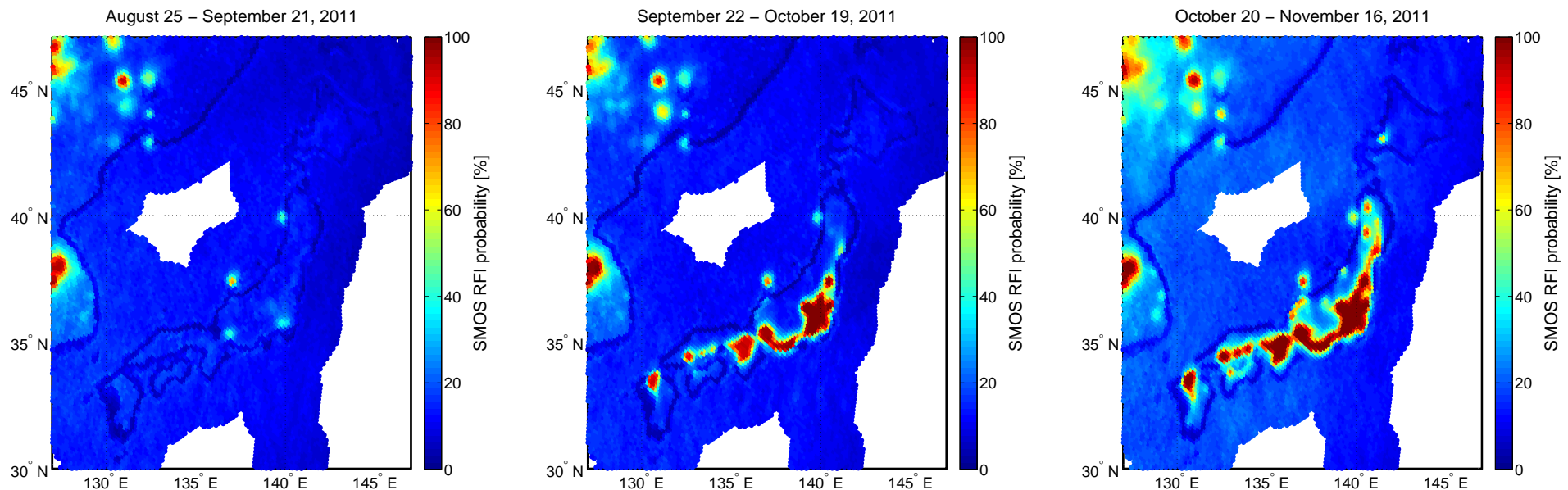


- Undetected RFI is a serious issue because it can unknowingly cause biases in retrieved salinity
- It is usually related to high level RFI but can also appear without it
- Cases of undetected RFI in two different areas of the world (Japan and North Atlantic) will be examined here

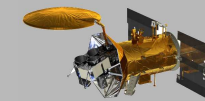
SMOS RFI Probability



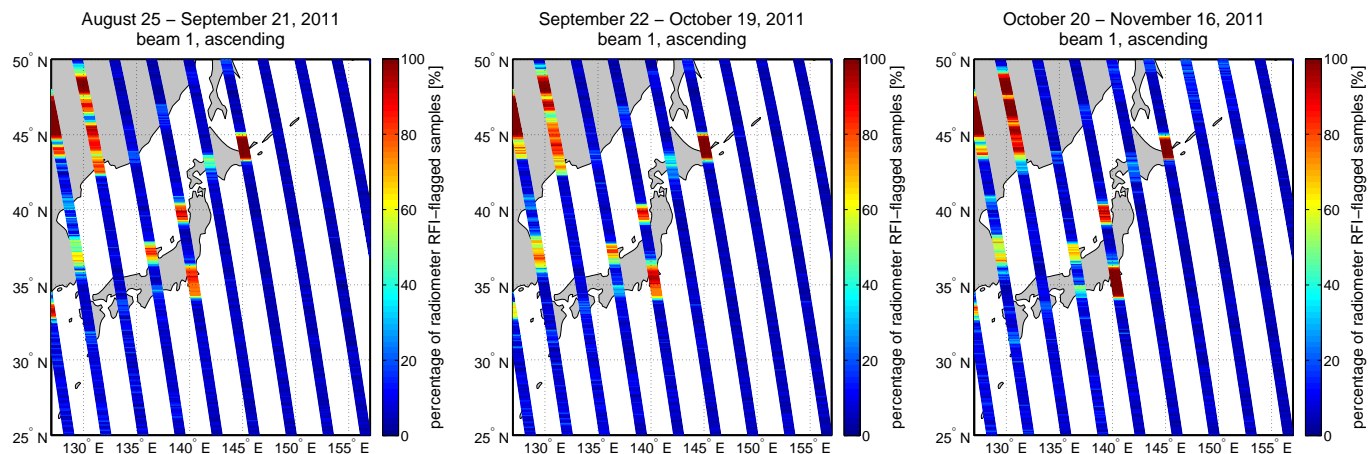
- SMOS detected a large increase of RFI over Japan starting September 2011
- Suspected cause: start of operation in frequency band adjacent (above) to Earth Exploration Satellite Service (EECS) primary allocation to passive remote sensing systems



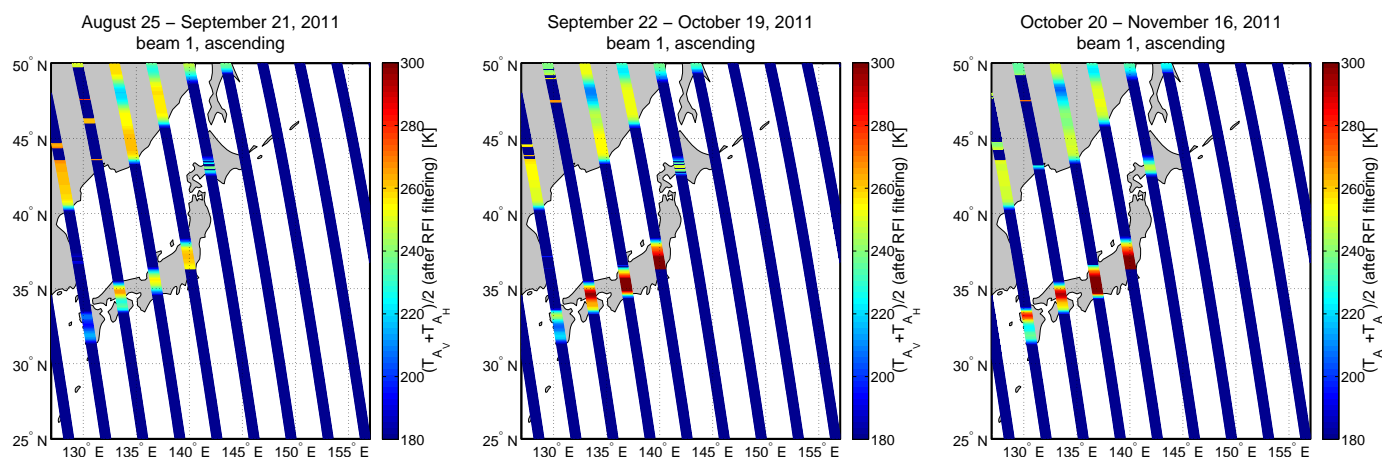
Aquarius RFI and antenna temperature (ascending)



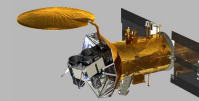
- no change in detected RFI...



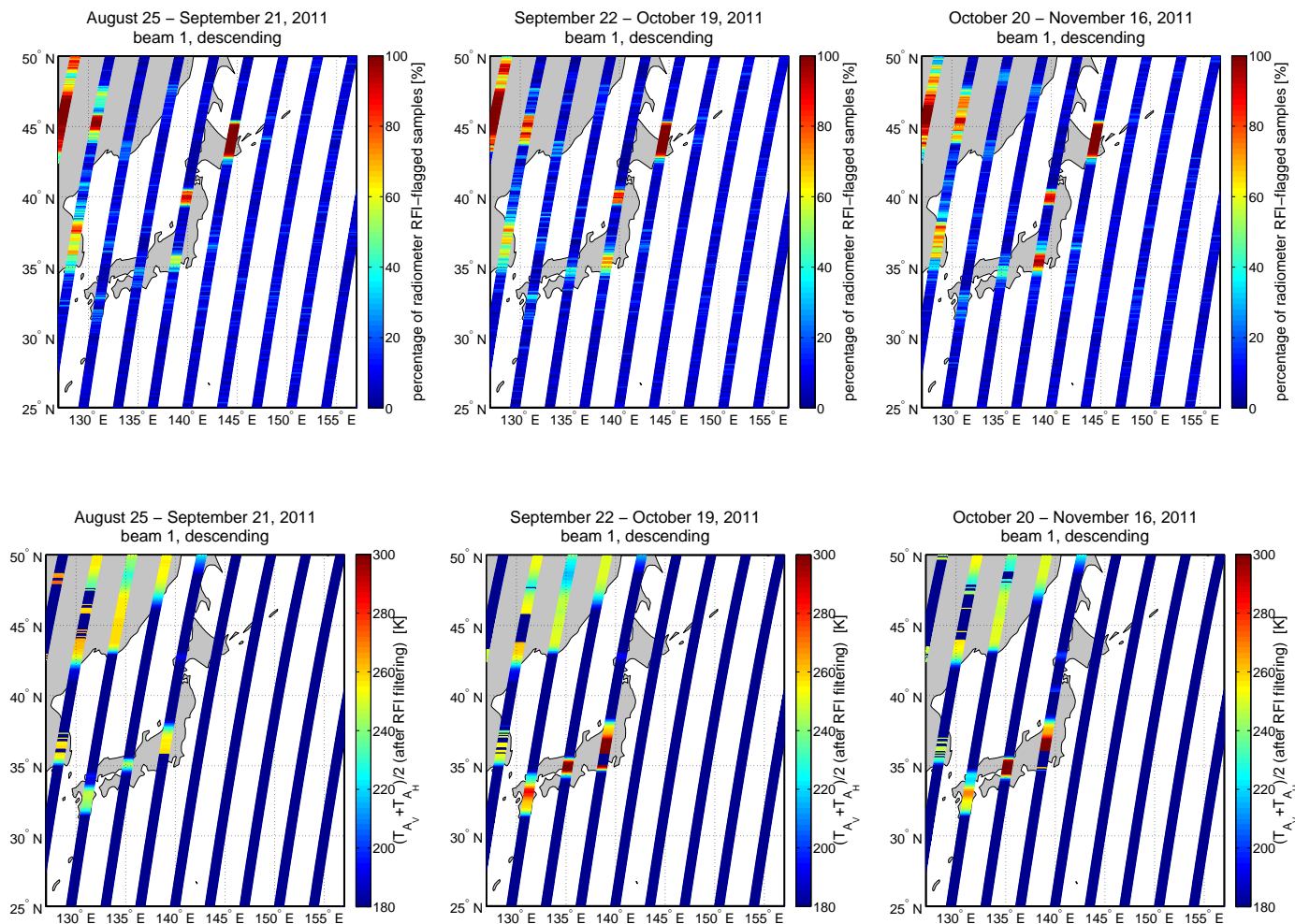
- but large change in observed antenna temperature!



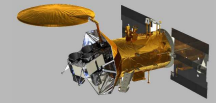
Aquarius RFI and antenna temperature (descending)



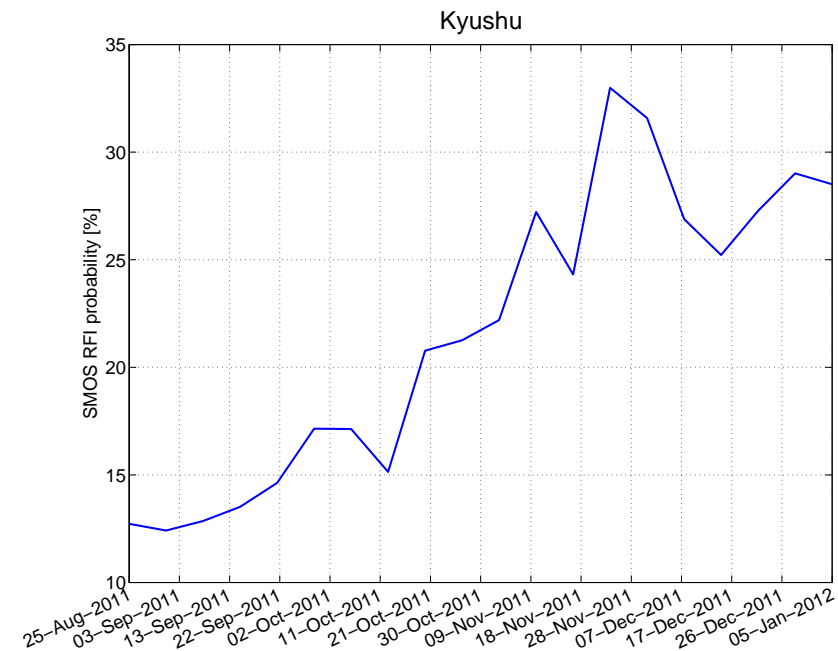
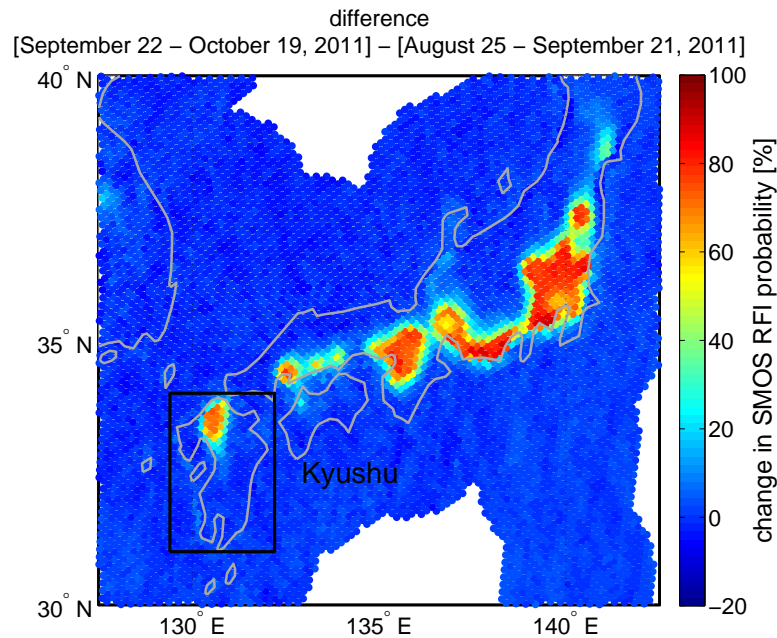
- same trend is observed in descending tracks (and beams 2,3)



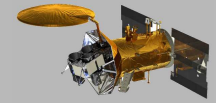
Analysis over Kyushu: SMOS RFI



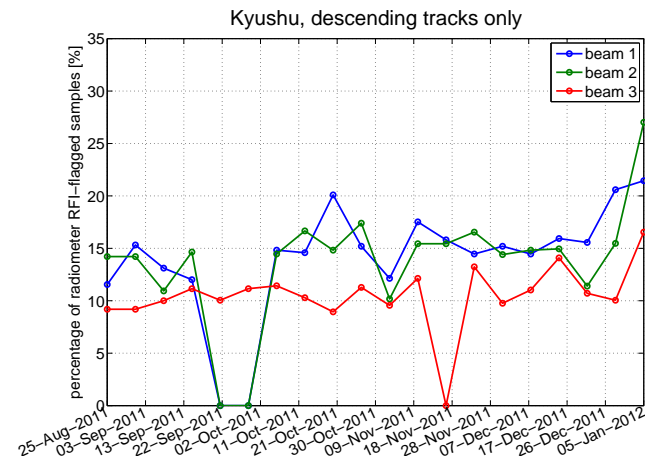
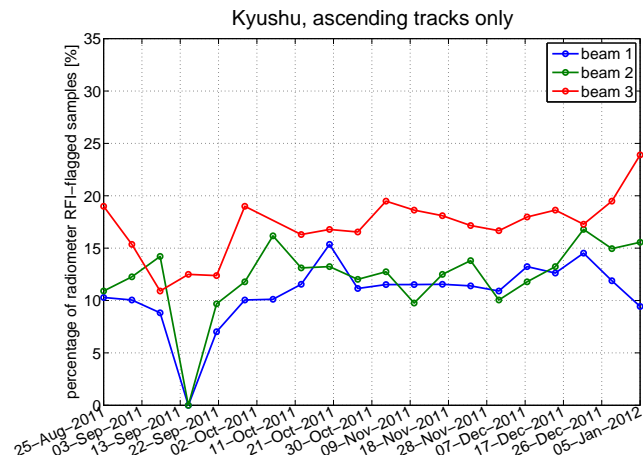
- Change is most evident over the island of Kyushu where little RFI had been detected before September 2011, by either SMOS or by Aquarius



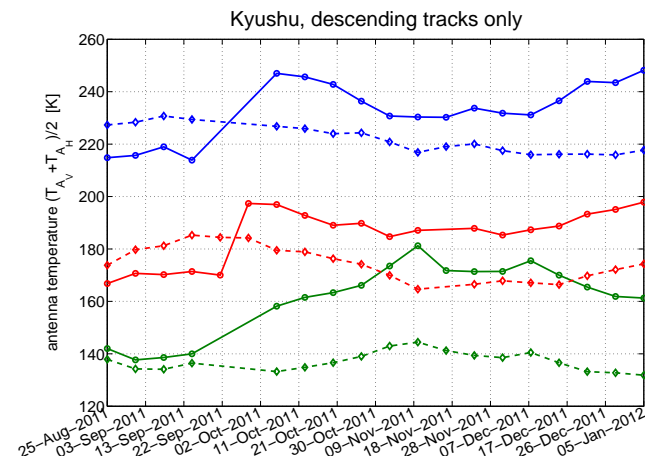
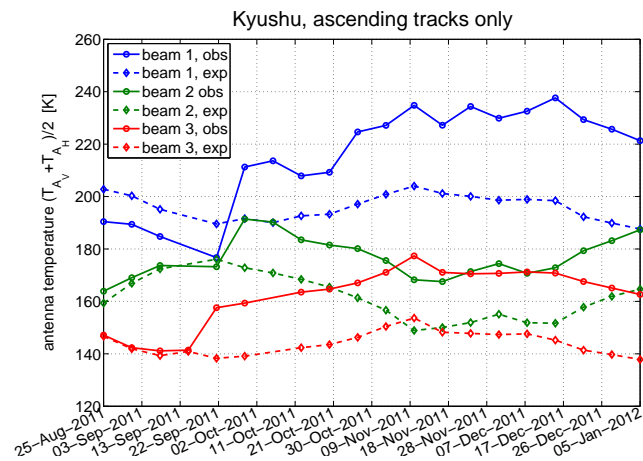
Analysis over Kyushu: Aquarius RFI and T_A



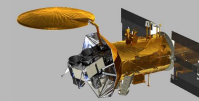
no recognizable change in Aquarius detected RFI...



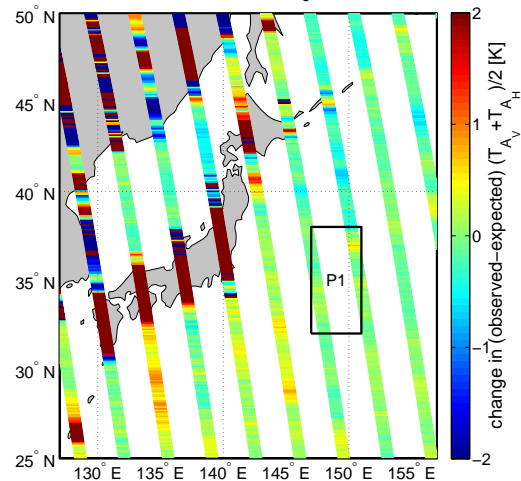
but definite change in Aquarius observed antenna temperature compared to expected antenna temperature



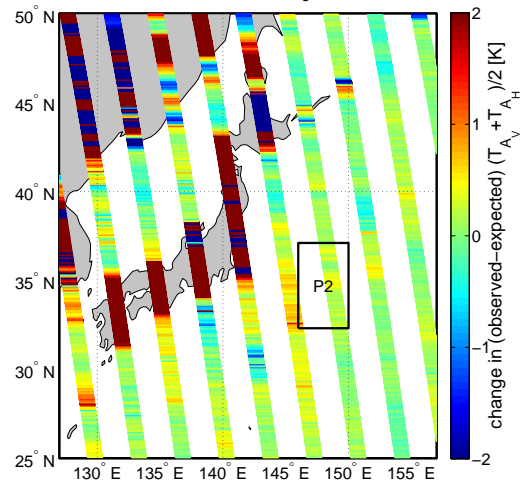
Analysis over Pacific Ocean, Region P



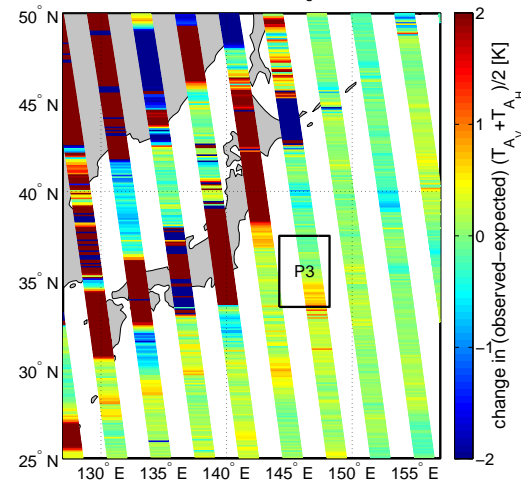
[September 22 – October 19, 2011] – [August 25 – September 21, 2011]
beam 1, ascending



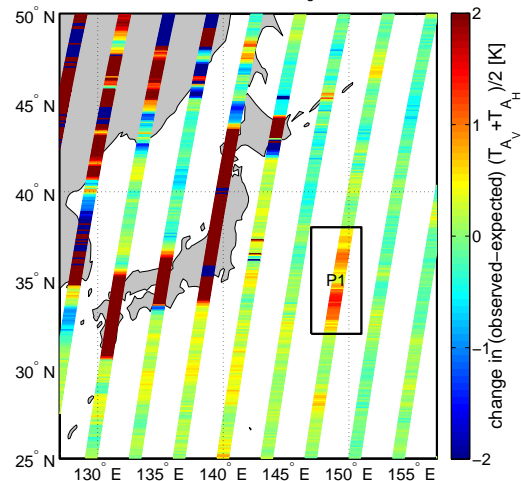
[September 22 – October 19, 2011] – [August 25 – September 21, 2011]
beam 2, ascending



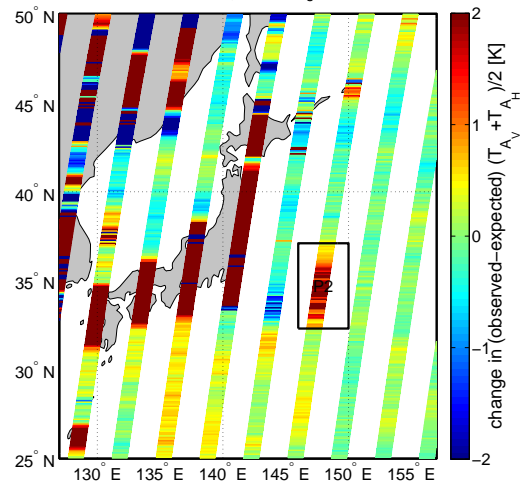
[September 22 – October 19, 2011] – [August 25 – September 21, 2011]
beam 3, ascending



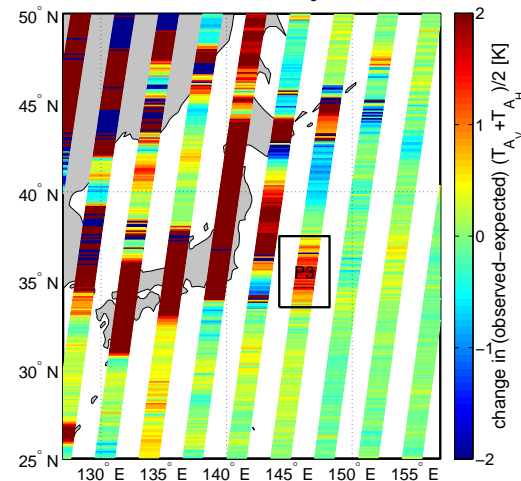
[September 22 – October 19, 2011] – [August 25 – September 21, 2011]
beam 1, descending



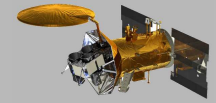
[September 22 – October 19, 2011] – [August 25 – September 21, 2011]
beam 2, descending



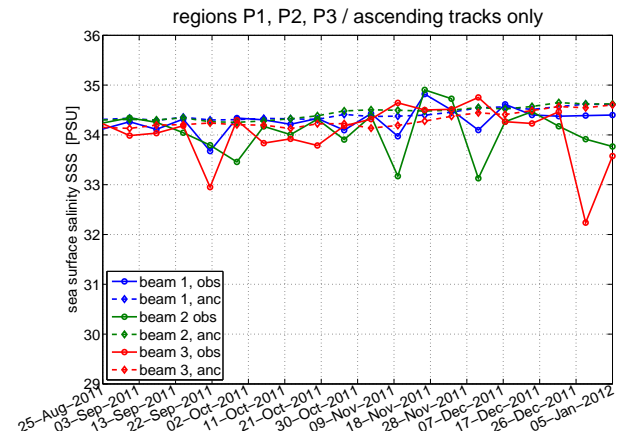
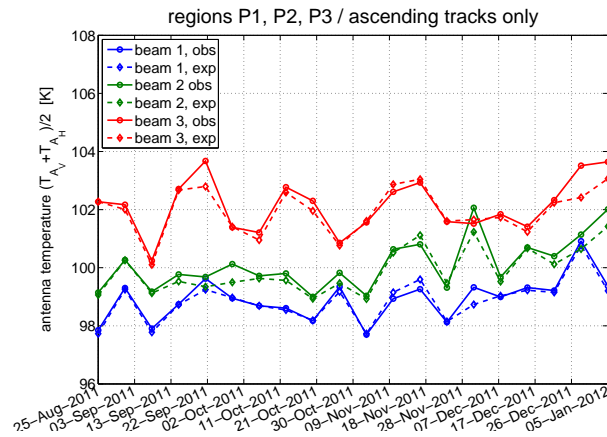
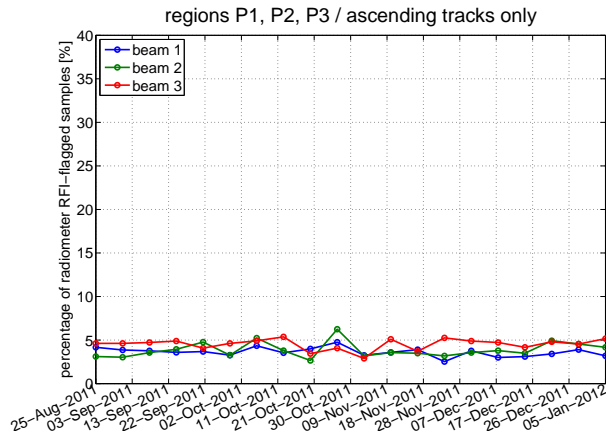
[September 22 – October 19, 2011] – [August 25 – September 21, 2011]
beam 3, descending



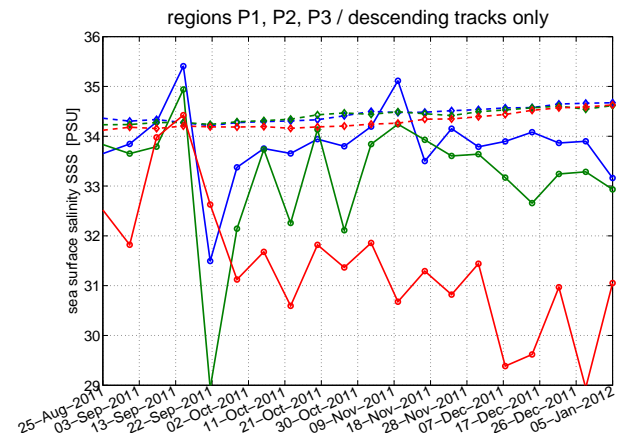
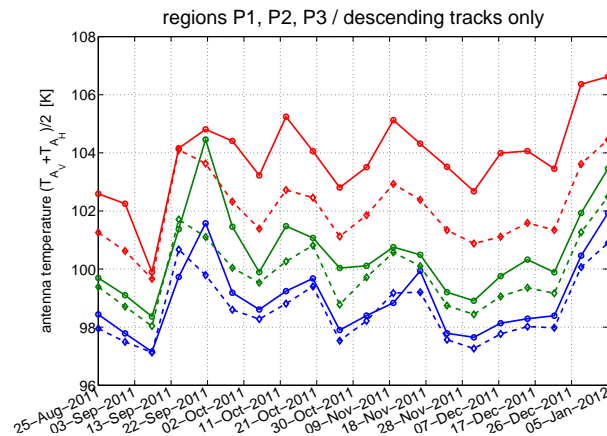
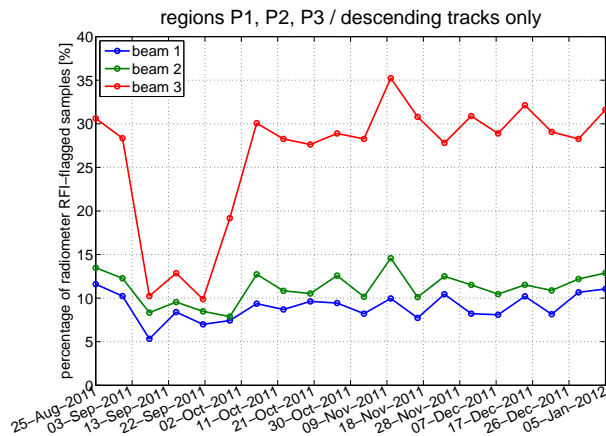
Analysis of Region P: Aquarius Observations



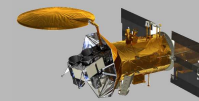
ascending



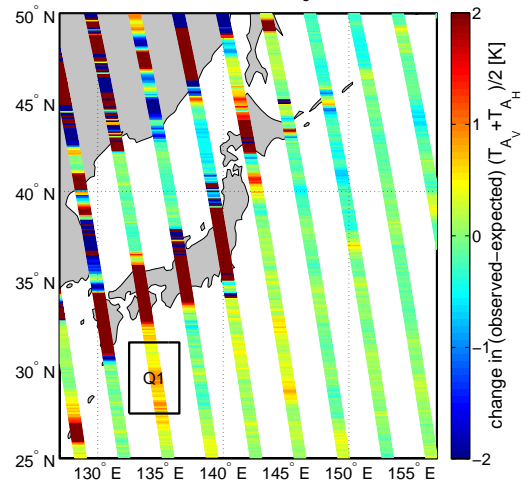
descending



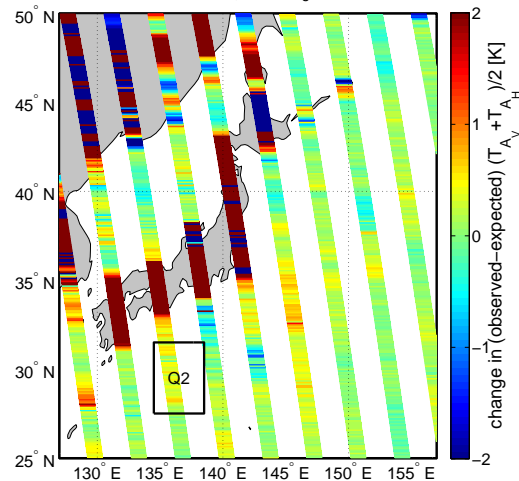
Analysis over Pacific Ocean, Region Q



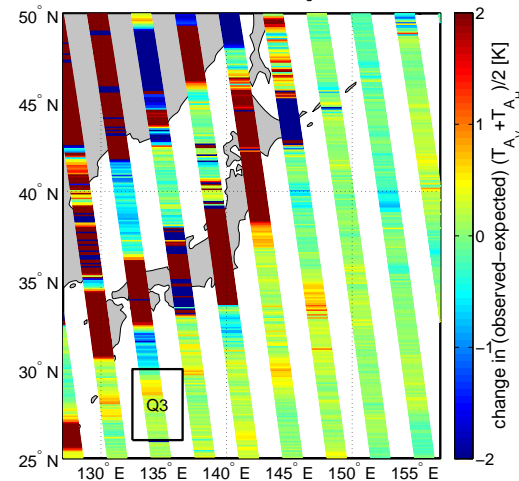
[September 22 – October 19, 2011] – [August 25 – September 21, 2011]
beam 1, ascending



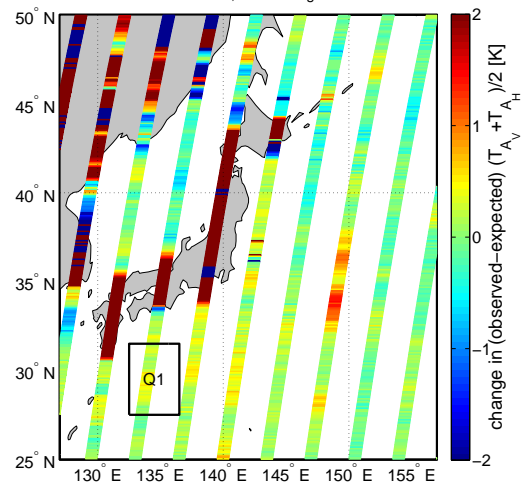
[September 22 – October 19, 2011] – [August 25 – September 21, 2011]
beam 2, ascending



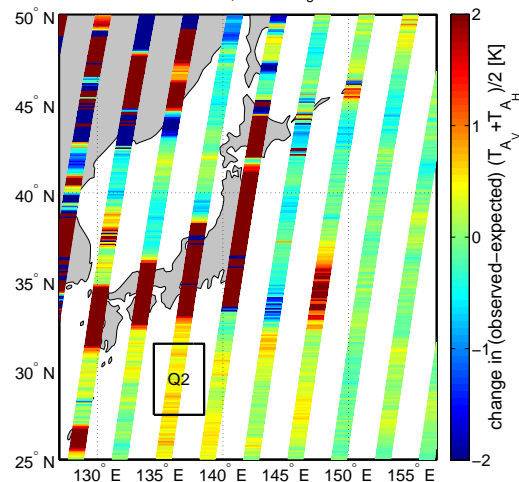
[September 22 – October 19, 2011] – [August 25 – September 21, 2011]
beam 3, ascending



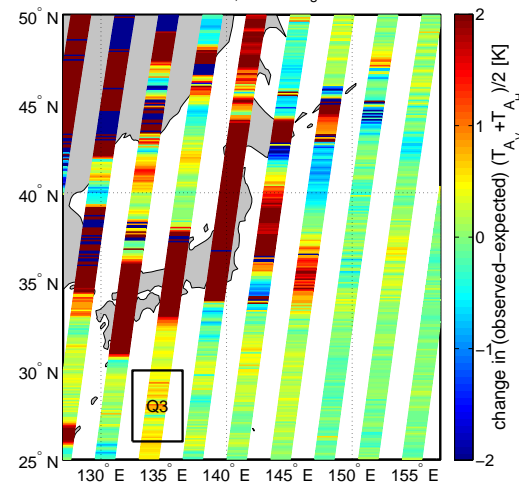
[September 22 – October 19, 2011] – [August 25 – September 21, 2011]
beam 1, descending



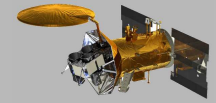
[September 22 – October 19, 2011] – [August 25 – September 21, 2011]
beam 2, descending



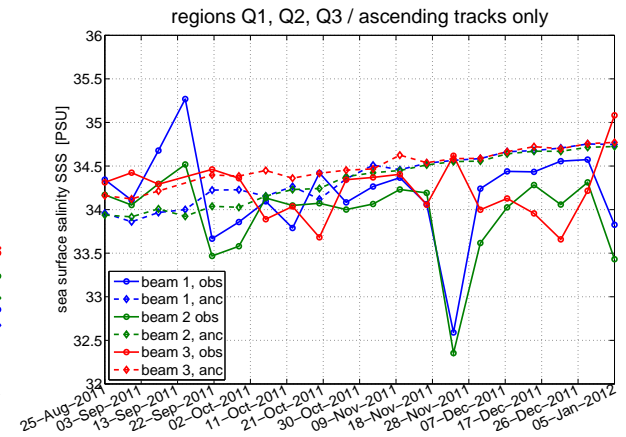
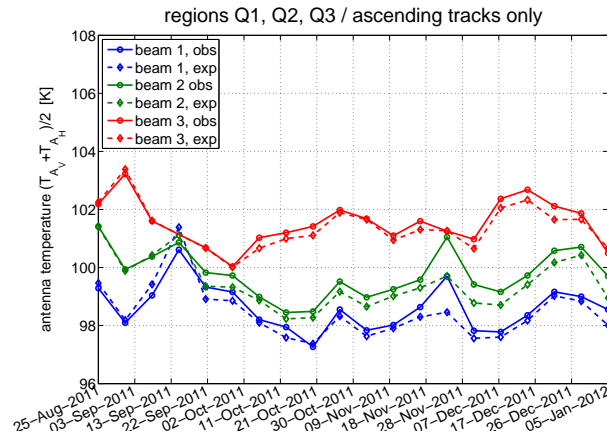
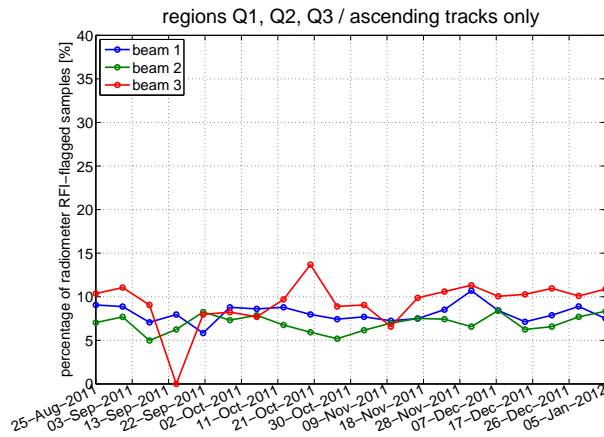
[September 22 – October 19, 2011] – [August 25 – September 21, 2011]
beam 3, descending



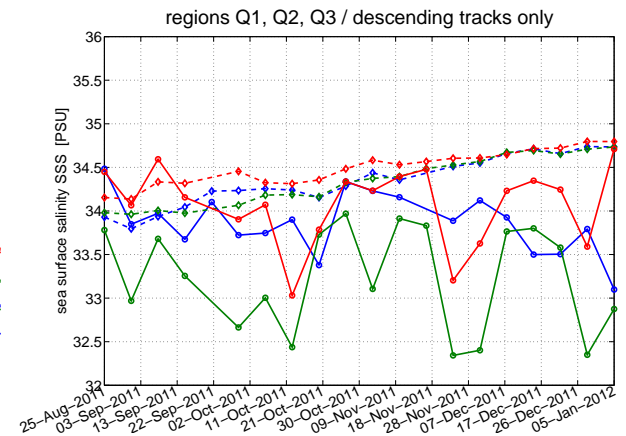
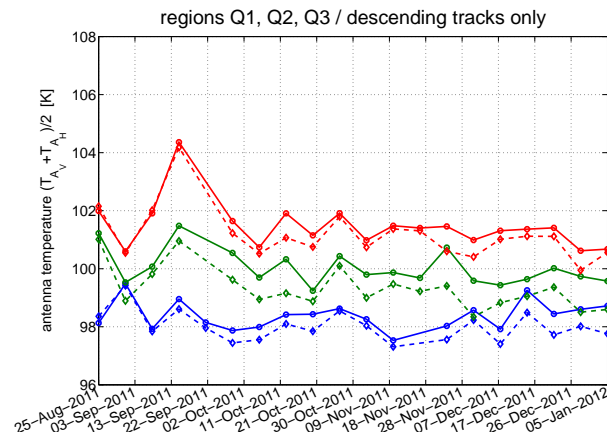
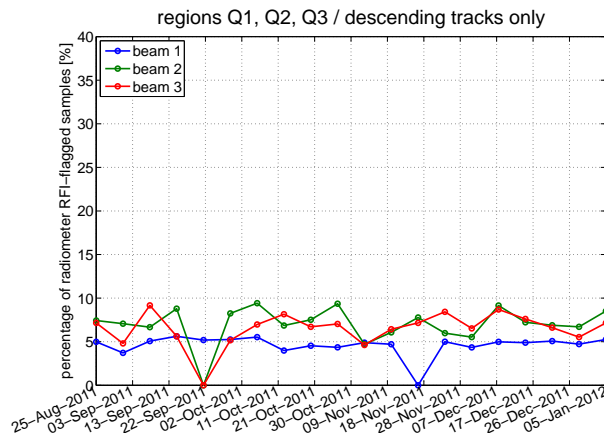
Analysis of Region Q: Aquarius Observations

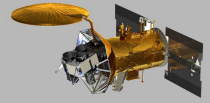


ascending



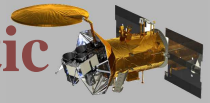
descending



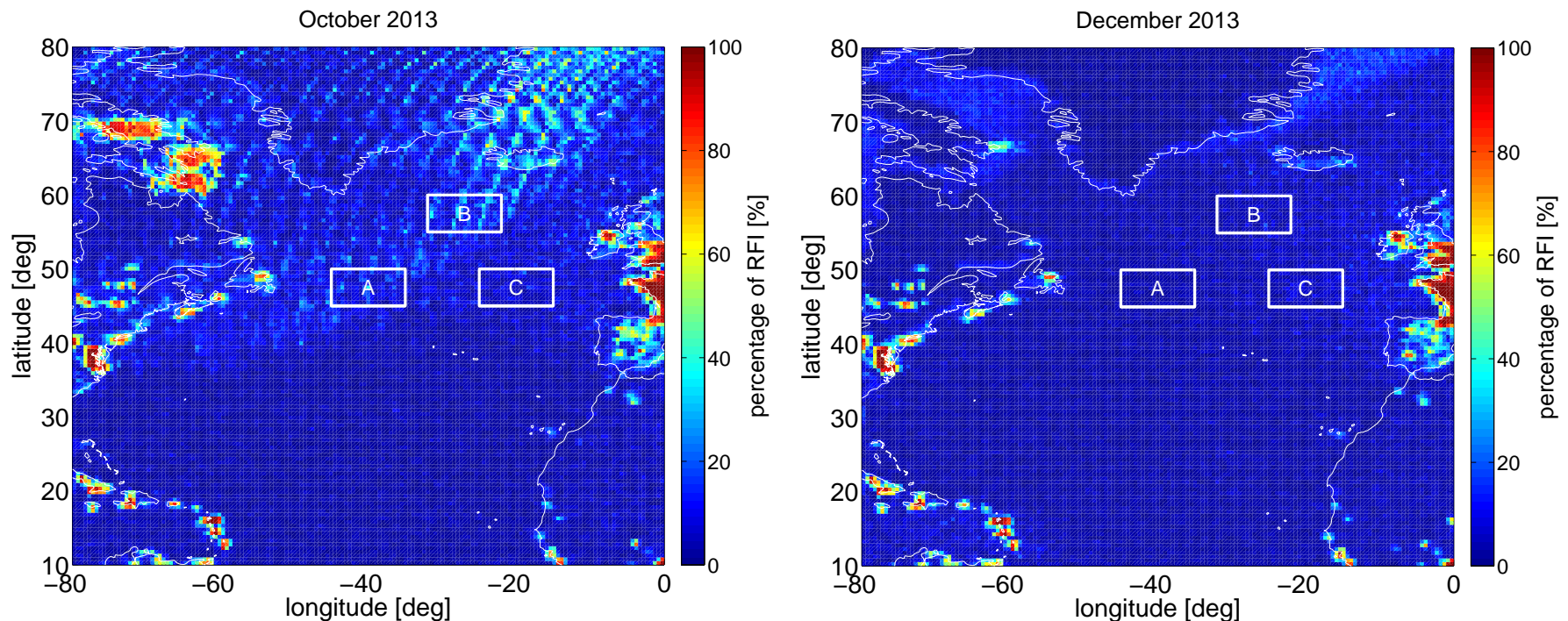


- Aquarius RFI filter is missing most of the RFI emitted by wireless telecommunication systems
- Quantifying the effect on SSS and soil moisture retrievals is difficult due to the short time range range of RFI-free measurements (4 weeks)
- Effect is very large over land but present, although almost undetectable, over ocean as well
- Further analysis are mostly confined to the area around Kyushu due to presence of radar systems RFI on other parts of Japan

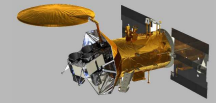
Change in RFI Environment in Canada and North Atlantic



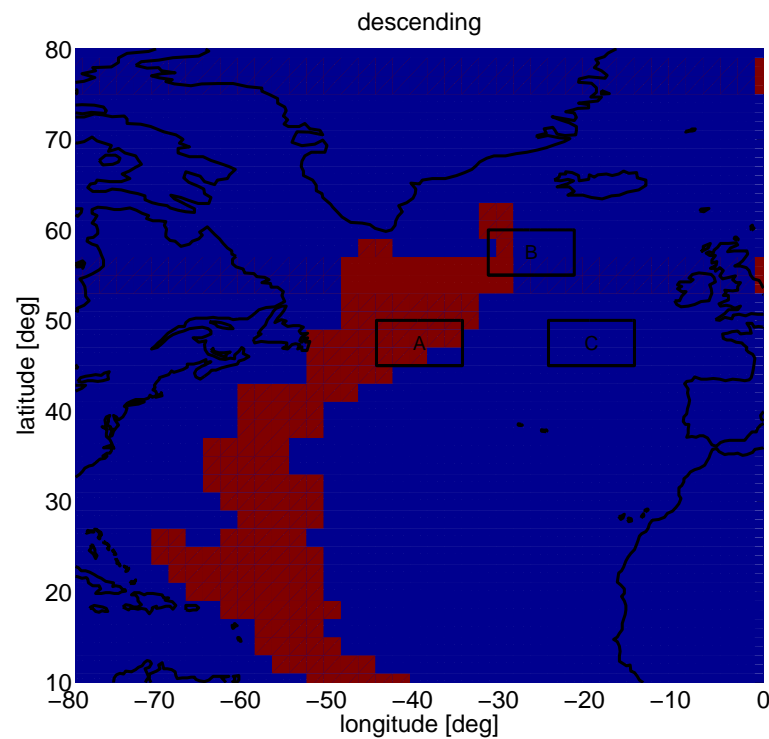
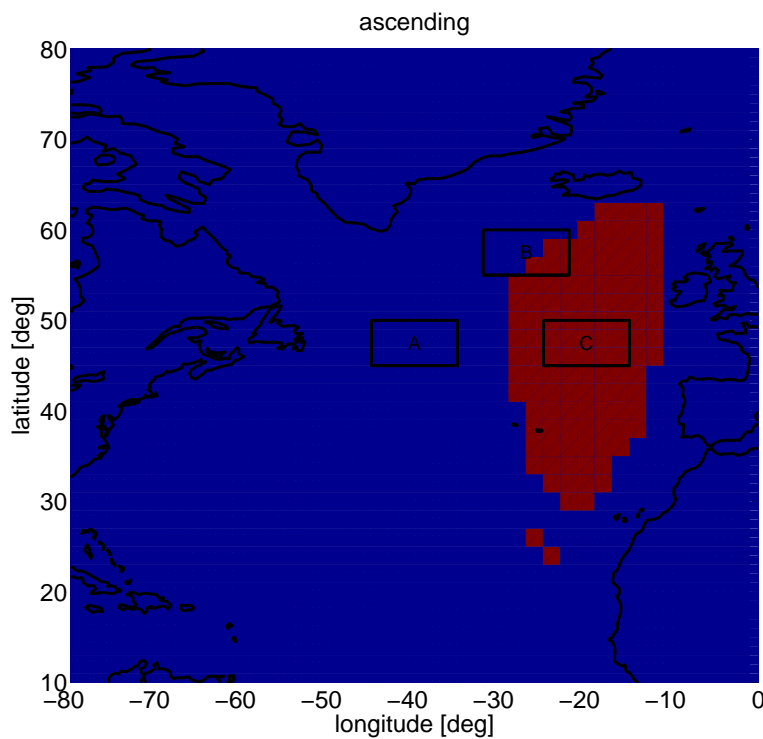
- Following requests by SMOS, in November 2013 radars part of the North Warning System (formerly DEW Line) adjusted their operating frequency to avoid interference in the 1400 to 1427 MHz band
- As a result, most antenna sidelobe RFI over the Eastern part of the North Atlantic disappeared starting on November 26, 2013
- An analysis has been performed on selected regions, findings shown here are limited to three of them



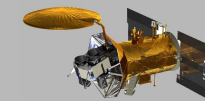
Characteristics of Selected Study Regions



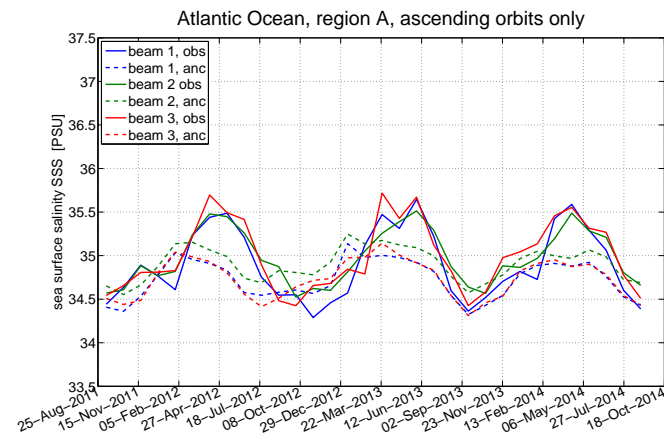
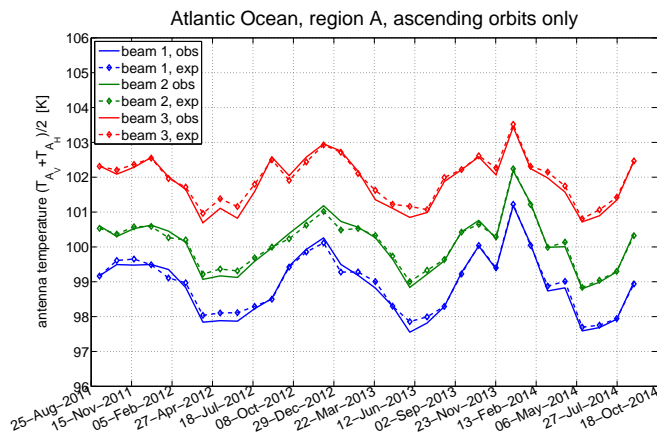
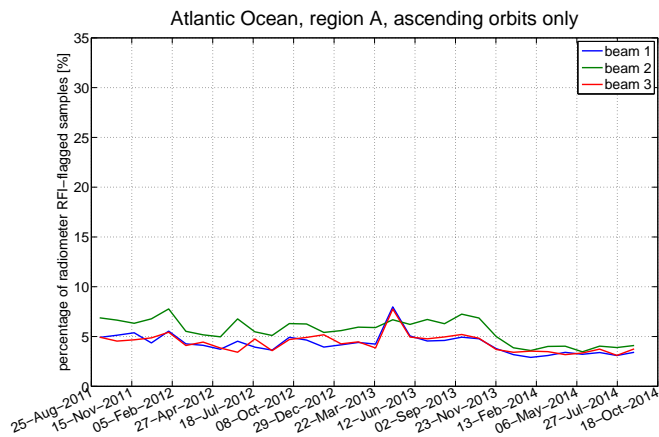
- Regions under study partially overlap “RFI exclusion zone” that is not used for calibration, and include
 - an area moderately affected by RFI emissions from Canada (region A)
 - an area severely affected by RFI emissions from Canada (region B)
 - an area affected by RFI emissions from Europe (region C)



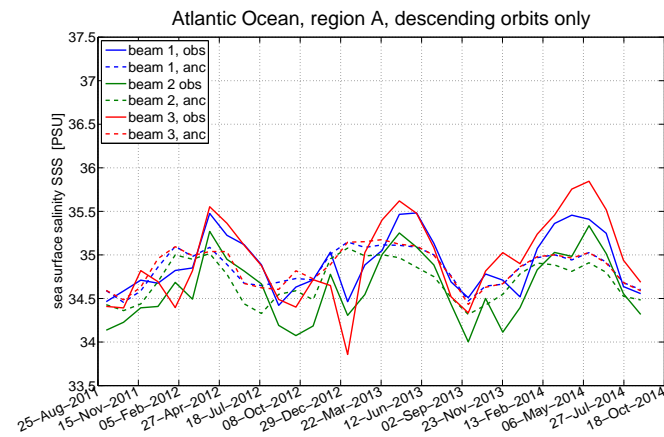
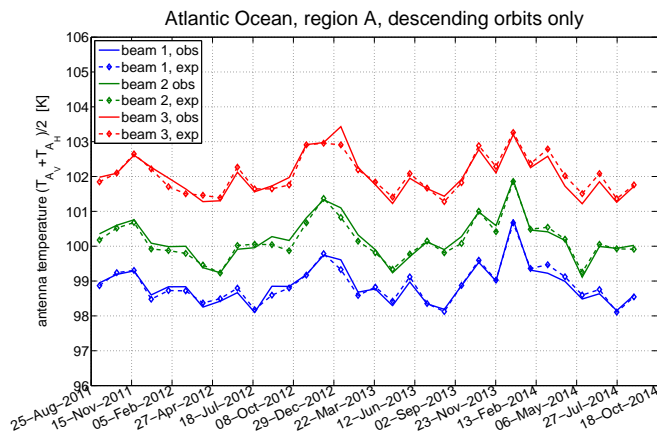
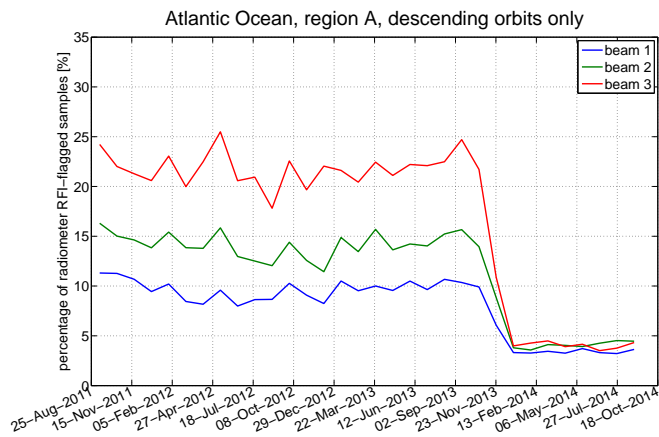
North Atlantic Region A



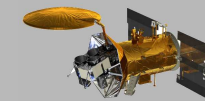
ascending



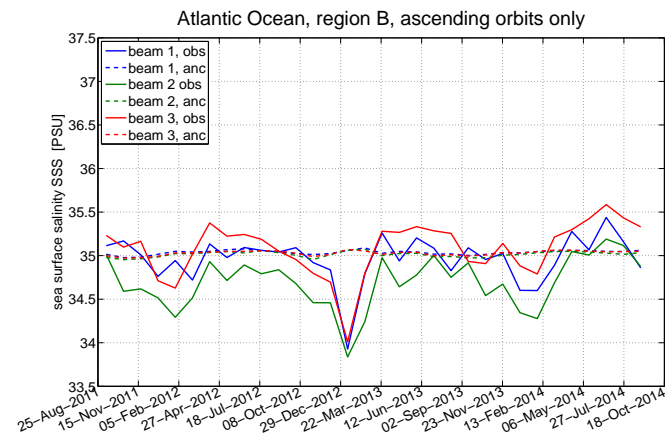
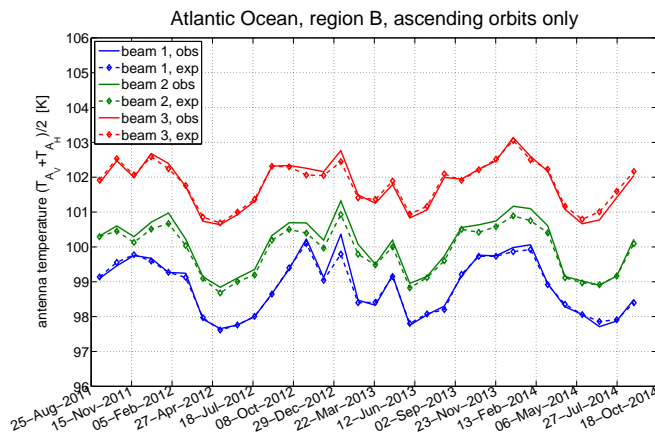
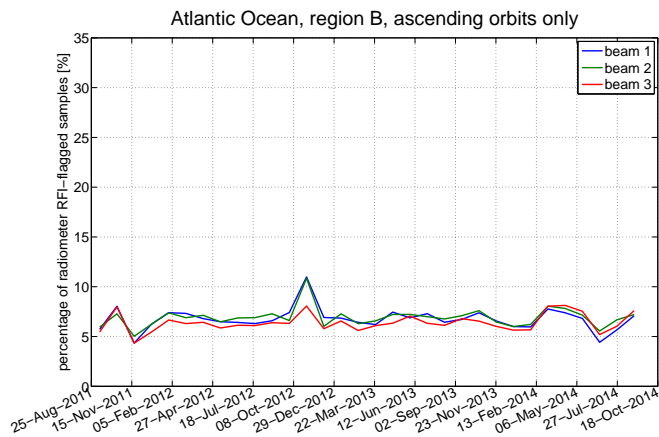
descending



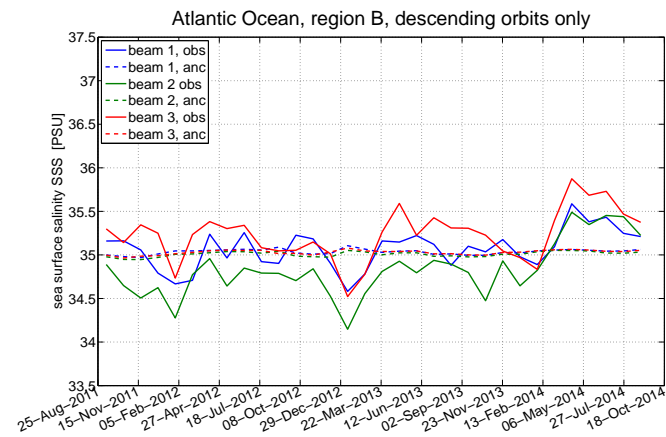
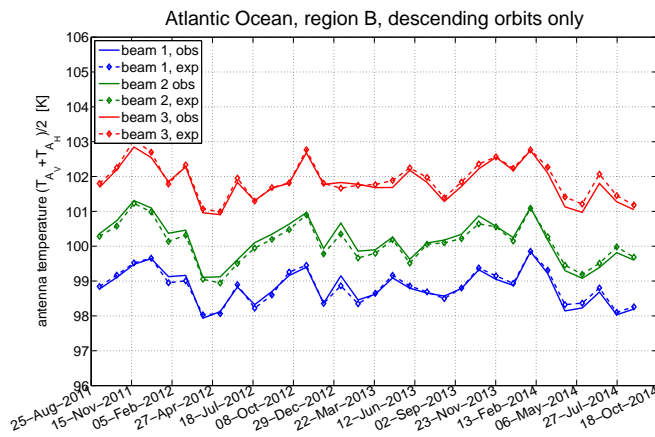
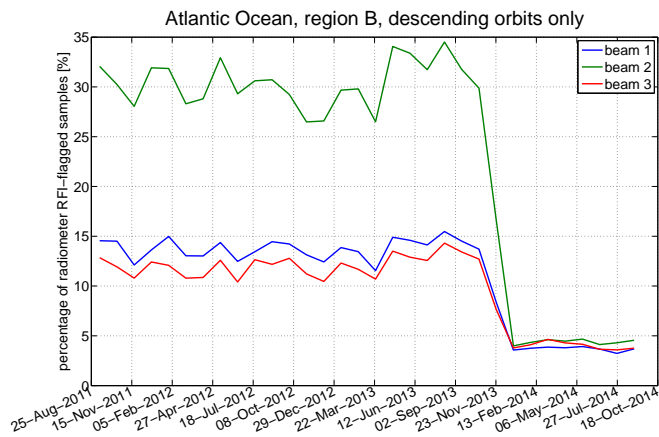
North Atlantic Region B



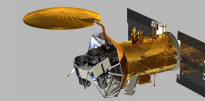
ascending



descending

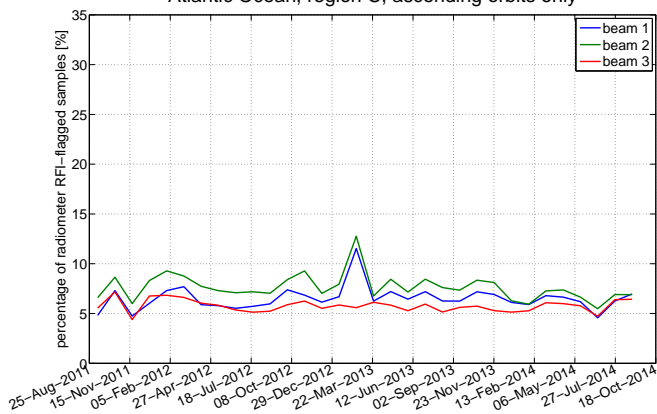


North Atlantic Region C

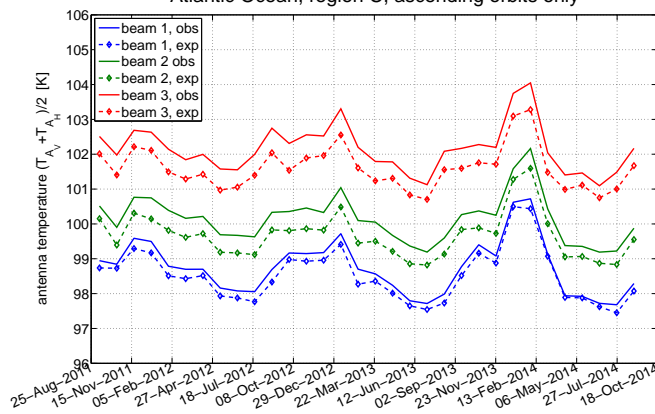


ascending

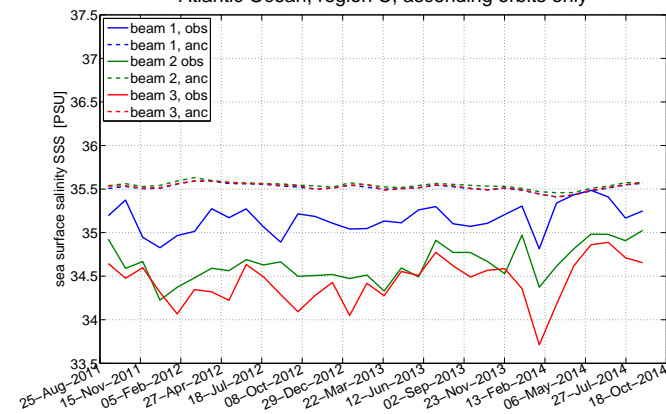
Atlantic Ocean, region C, ascending orbits only



Atlantic Ocean, region C, ascending orbits only

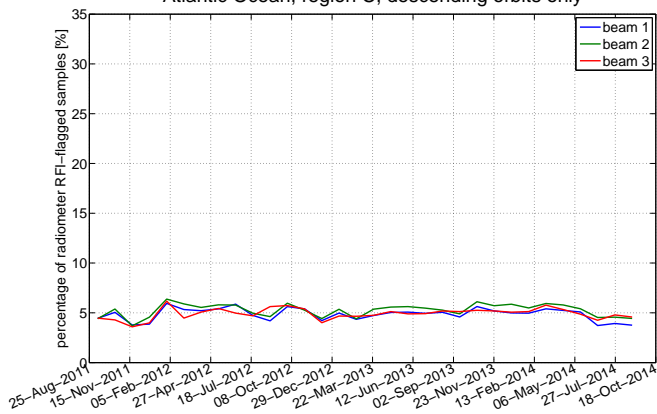


Atlantic Ocean, region C, ascending orbits only

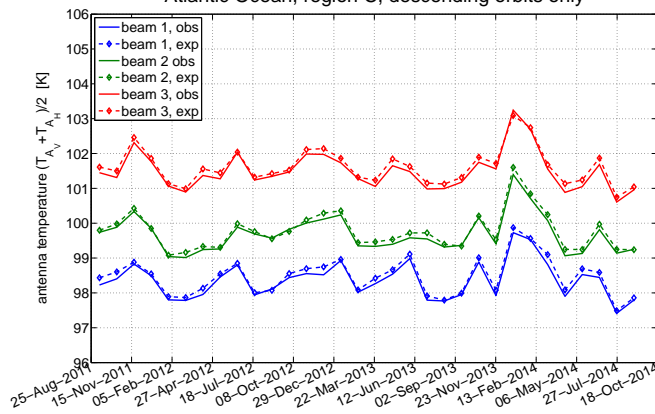


descending

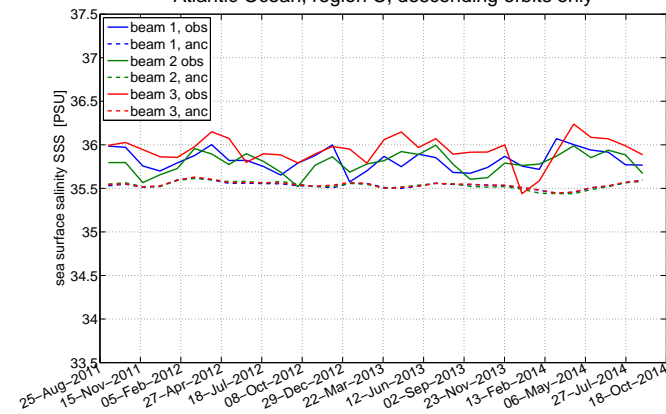
Atlantic Ocean, region C, descending orbits only



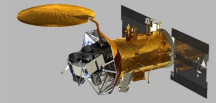
Atlantic Ocean, region C, descending orbits only



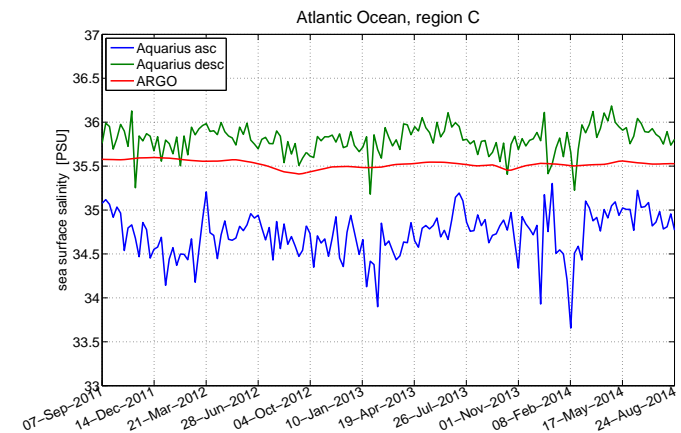
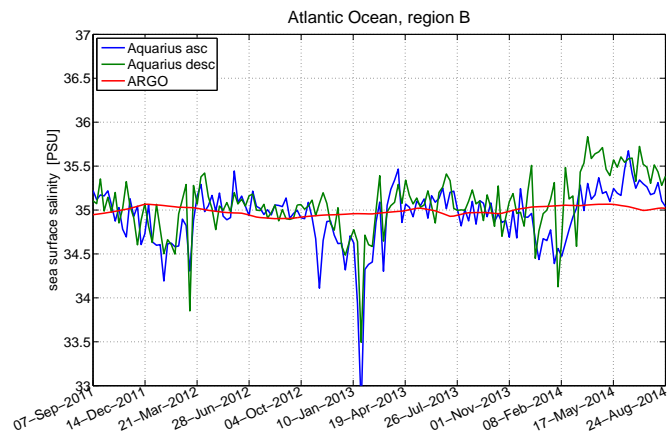
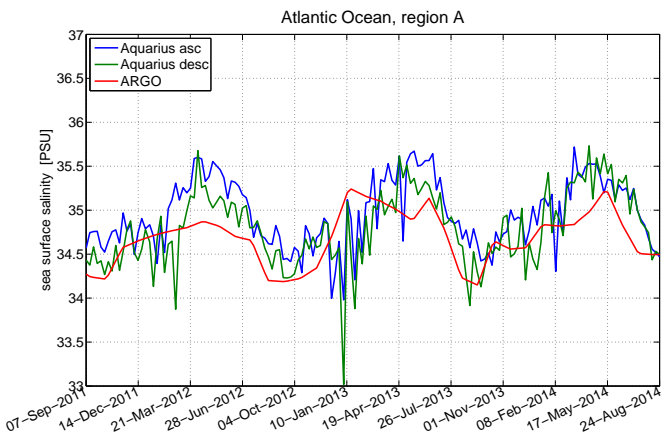
Atlantic Ocean, region C, descending orbits only



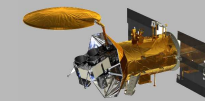
Comparison with ARGO SSS



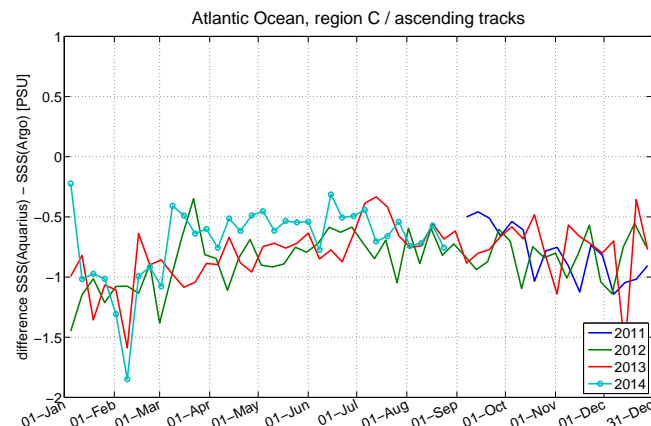
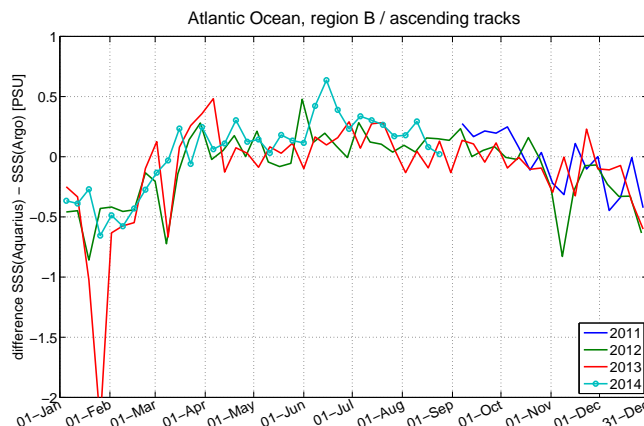
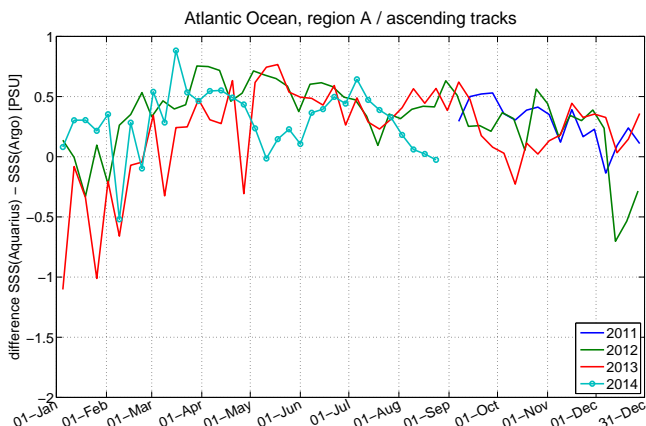
- comparison with ARGO data shows a similar trend



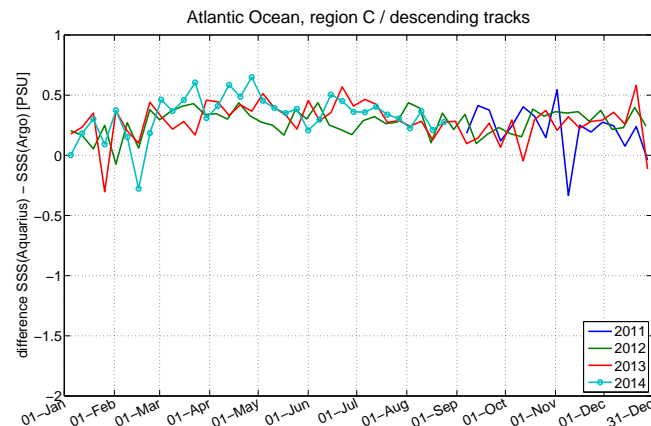
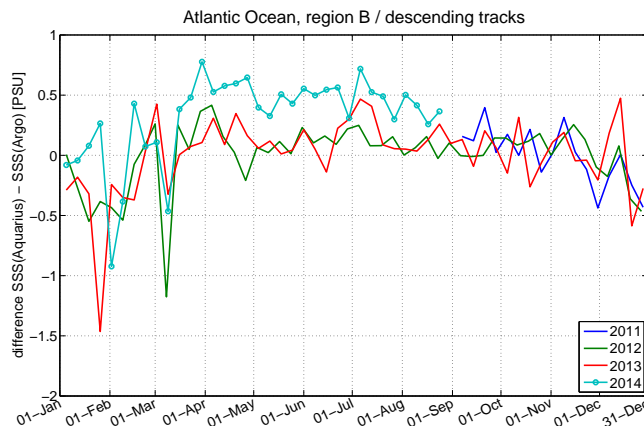
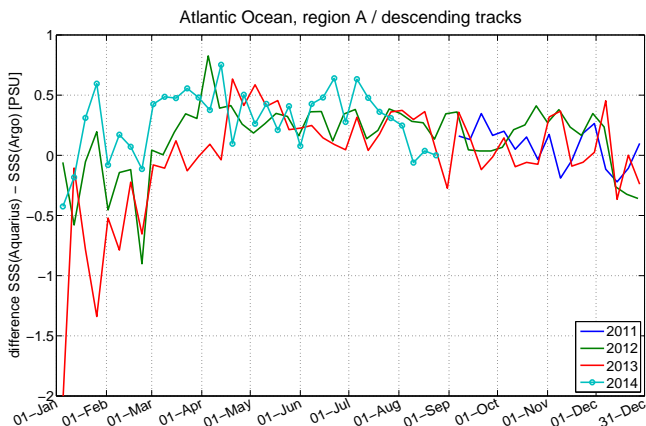
Year-by-Year Comparison with ARGO SSS



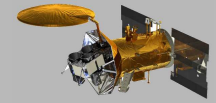
ascending



descending



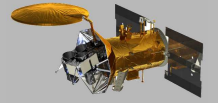
Estimation of SSS Bias Caused by Undetected RFI



		region A	region B	region C
ARGO SSS (2) - ARGO SSS (1)		-0.0077	0.0579	-0.0062
AQ SSS (2) - AQ SSS (1)	asc+desc	0.1043	0.2593	0.0796
	asc	0.0281	0.1763	0.1265
	desc	0.1806	0.3423	0.0327
estimated bias in Aquarius SSS caused by undetected RFI?	asc+desc	0.1120	0.2014	0.0858
	asc	0.0358	0.1184	0.1327
	desc	0.1883	0.2844	0.0389

- (1) \implies average of (23-Nov-2011 to 23-Aug-2012) and (22-Nov-2012 to 24-Aug-2013)
- (2) \implies (23-Nov-2013 to 24-Aug-2014)

units are PSU



- Aquarius RFI filter is missing some RFI, need to add a way to detect it?
- possibility of unexpected undetected RFI must be taken into consideration for calibration
- use of SMOS RFI product can help in some analysis