Numerical Weather Prediction

ERS-2 scatterometer - reintroduction into the Met Office global model

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Contents.

Executive Summary.

ERS-2 AMI data have been successfully assimilated recently in a forecast trial alongside SEAWINDS observations. This is the first time that the Scatwind processing system has ever had to cope with more than one scatterometer at a time. These trial results show a neutral impact and (together with recent monitoring statistics generated at the Met Office) give us increased confidence that we can allow ERS-2 AMI data to be assimilated operationally once again in order to add increased resilience to our observation system and a recommendation is made in this report to that effect.

1. Introduction.

ERS-2 AMI scatterometer data were operationally used from 1998 to 1999 (and before that, winds from an identical instrument on ERS-1 were assimilated from 1993). Unfortunately, due to Y2K issues and shortly afterwards technical problems with the ERS-2 platform, it was necessary in late December 1999 to black list the AMI observations and they were never re-introduced into the replacement assimilation scheme described in OSDP8. Today however, there is strong evidence that the AMI observations are of high quality and can be readily assimilated again to yield a benefit to NWP.

Both KNMI and ECMWF (at least) are known to be routinely assimilate ERS-2 AMI data again and monitoring has been performed at both institutes to show the long term stability of the instrument. The coverage of the instrument is limited mainly to the northern hemisphere due to the on board tape recorder failure on ERS-2. However, some southern hemisphere data is slowly becoming available again as additional national ground reception stations are brought on-line to capture the direct-readout stream. Figure 1 shows the coverage of useful ERS-2 AMI observations from 3rd November – 12th December 2005. Monitoring has also been performed in Satellite Applications on an ad-hoc basis. Figure 2 shows the O vs B wind speeds. The bias is very small for this period (< 0.05m/s) with a standard deviation of < 1.65m/s, though at high wind speeds (>20m/s) there does appear to be a small low bias in the observations if background values are regarded as truth.

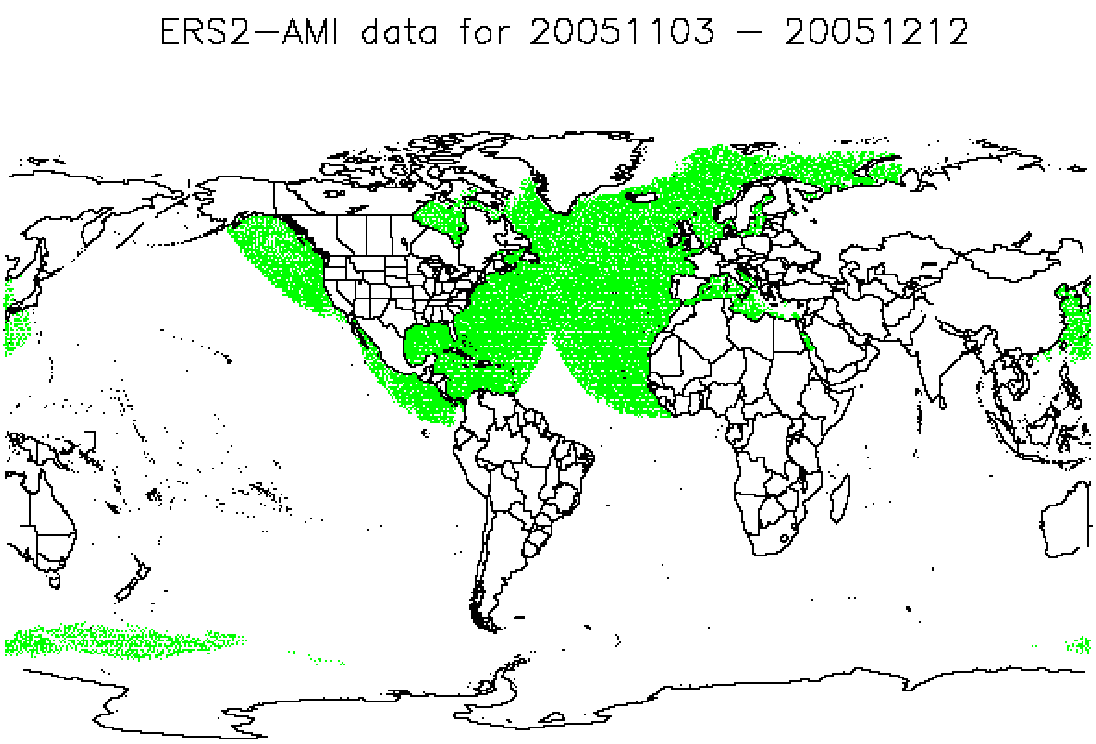

Figure 1. Recent total coverage of usable ERS-2 AMI scatterometer observations.

2. Monitoring of ERS-2 AMI data.

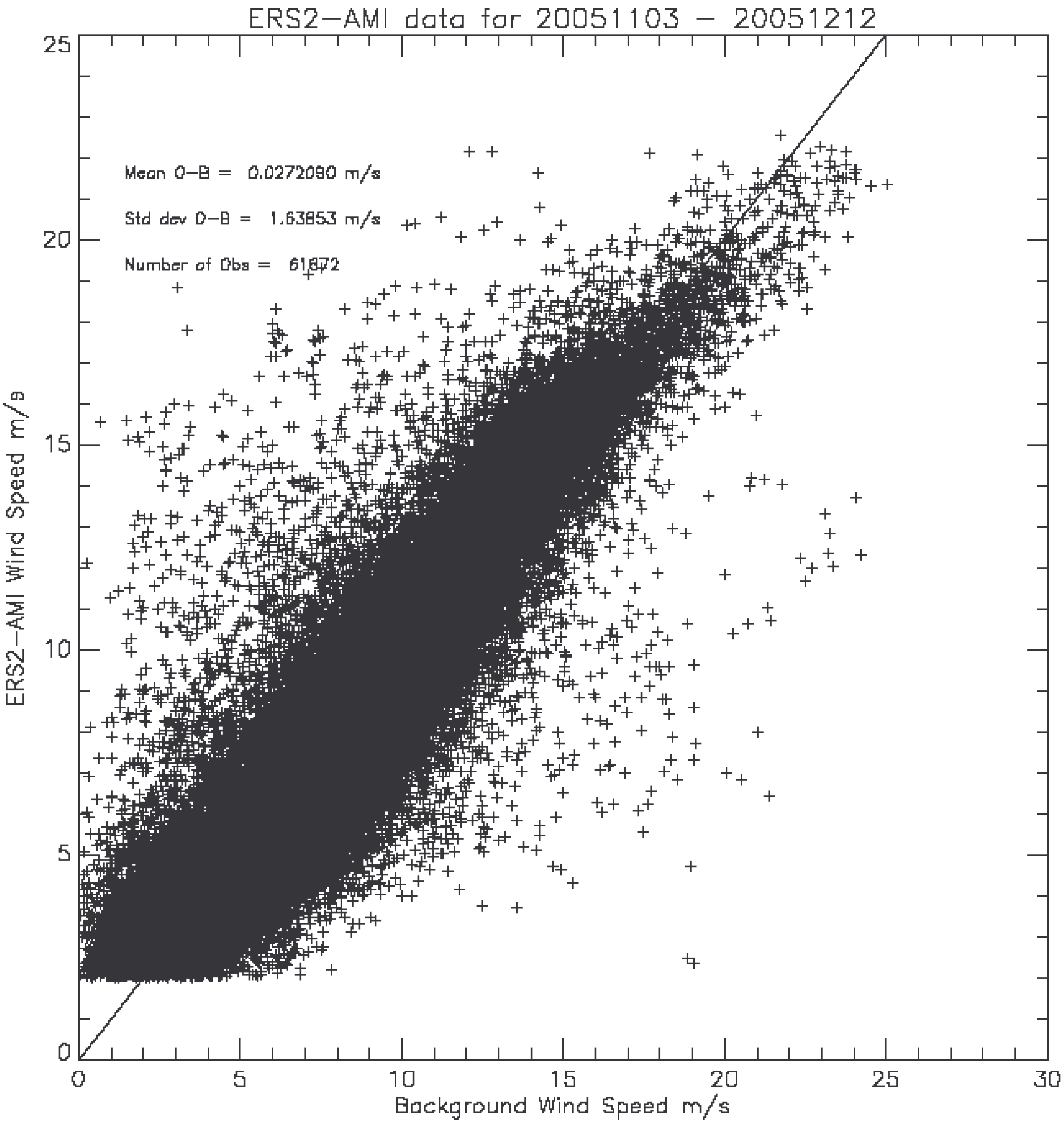

Figure 2. O-B wind speed for ERS-2 AMI. Bias is very low overall although at higher wind speeds it looks like ERS-2 AMI may slightly underestimate the wind speed, if the background fields can be relied upon.

A plot of current ERS-2 AMI and SEAWINDS data coverage for one model cycle is shown in Figure 3 below. It can be clearly seen that, although there is limited amounts of ERS-2 data, the AMI coverage is broadly complementary to that of SEAWINDS instrument.

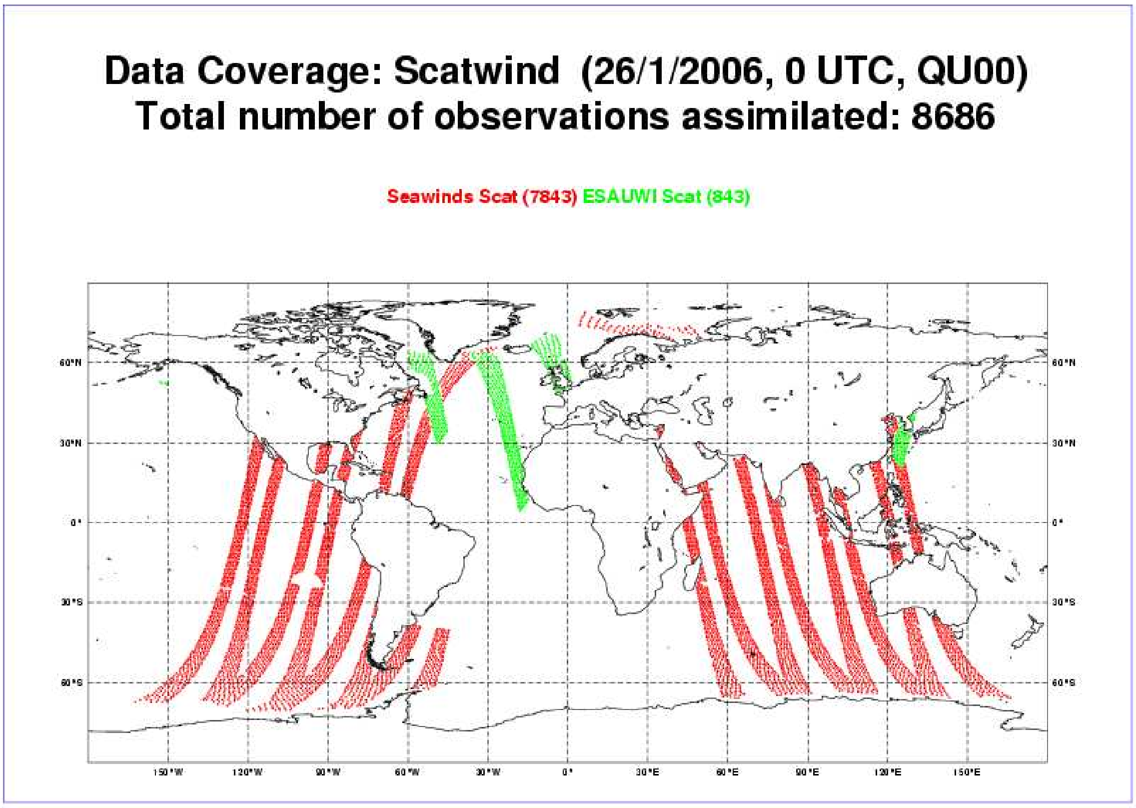

Figure 3. Example of scatterometer coverage for QU00 model run with ERS-2 AMI included.

3. Forecast trial on NEC.

In order to verify that the addition of ERS-2 AMI into the global model would not harm the forecast it was necessary to conduct a single season forecast trial. The trial period and job ids are shown in table 1 below. The trial was an N216 global 4D Var experiment.

Table 1. ERS-2 AMI forecast trial details.

TRIAL	OWNER	JOB ID	START DATE	END DATE	QUEUE	STATUS
1st Season trial vs scsvc						
scoyh vs scsvc	frsk	scoy.h	26/07/05 QU06	25/08/05 QU12	sx8 (tx03) night	Complete.

The headline verification results against observations are shown in Table 2 and verification against analysis values are shown in Table 3. The results demonstrate that there is a neutral impact from adding ERS-2 scatterometer data into the model in addition to SEAWINDS data. This is true with respect to verification against both observations and analyses.

This is a very important result for two reasons. Firstly this result enables us to add more resilience into the model system by providing some limited backup for North Atlantic SEAWINDS observations should the SEAWINDS scatterometer fail or be withdrawn from service before ASCAT data becomes operational. Secondly, this trial represents the first time that data from two scatterometers has passed through the OPS and VAR code at the same time. This gives increased confidence that the code is robust enough to handle ASCAT data (with some instrument-specific modification) without causing problems to the assimilation system.

Table 2. Verification of ERS-2 AMI addition against OBSERVATIONS.
Green--> Better; Red--> Worse; White--> Neutral

Parameter Details				No of Values	Control Data			Test Data			Differences		
Area	Field Code	Fc Range	Wt	12Z	Fc RMS	Per RMS	Wted Skill	Fc RMS	Per RMS	Wted Skill	Fc RMS Diff (%)	Skill Diff	UnWted Diff
NH	PMSL	T+24	10	29	1.269	3.963	8.975	1.272	3.960	8.968	0.23	-0.01	0.00
NH	PMSL	T+48	8	29	1.706	5.520	7.236	1.708	5.516	7.233	0.08	0.00	0.00
NH	PMSL	T+72	6	28	2.270	6.278	5.216	2.269	6.272	5.215	-0.02	0.00	0.00
NH	PMSL	T+96	4	27	3.039	6.652	3.165	3.041	6.647	3.163	0.08	0.00	0.00
NH	PMSL	T+120	4	26	4.029	6.903	2.637	4.038	6.898	2.629	0.23	-0.01	0.00
NH	H500	T+24	6	29	14.349	40.644	5.252	14.348	40.658	5.253	0.00	0.00	0.00
NH	H500	T+48	4	29	18.186	59.460	3.626	18.205	59.466	3.625	0.11	0.00	0.00
NH	H500	T+72	2	28	24.700	69.214	1.745	24.607	69.218	1.747	-0.38	0.00	0.00
NH	W250	T+24	12	29	6.046	17.062	10.493	6.048	17.062	10.492	0.03	0.00	0.00
Trop	W850	T+24	5	29	4.459	4.945	0.935	4.444	4.943	0.958	-0.32	0.02	0.00
Trop	W850	T+48	3	29	4.883	5.902	0.946	4.871	5.885	0.944	-0.25	0.00	0.00
Trop	W850	T+72	2	28	5.170	6.140	0.582	5.174	6.132	0.576	0.07	-0.01	0.00
Trop	W250	T+24	6	29	6.158	9.190	3.305	6.119	9.178	3.333	-0.63	0.03	0.00
SH	PMSL	T+24	5	29	1.433	6.582	4.763	1.433	6.583	4.763	0.02	0.00	0.00
SH	PMSL	T+48	4	29	2.034	9.080	3.799	2.031	9.081	3.800	-0.16	0.00	0.00
SH	PMSL	T+72	3	28	2.803	10.072	2.768	2.794	10.072	2.769	-0.30	0.00	0.00
SH	PMSL	T+96	2	27	3.796	10.299	1.728	3.770	10.300	1.732	-0.71	0.00	0.00
SH	PMSL	T+120	2	26	4.865	10.314	1.555	4.829	10.314	1.562	-0.73	0.01	0.00
SH	H500	T+24	3	29	14.576	67.368	2.860	14.587	67.362	2.859	0.08	0.00	0.00
SH	H500	T+48	2	29	20.920	94.925	1.903	20.935	94.943	1.903	0.07	0.00	0.00
SH	H500	T+72	1	28	29.851	107.024	0.922	29.904	107.041	0.922	0.18	0.00	0.00
SH	W250	T+24	6	29	6.461	22.844	5.520	6.468	22.851	5.519	0.12	0.00	0.00

```
Total Weighted Mean Skill (total weight = 100)
  Control Case    =   79.931
  Test Case       =   79.965
  Test - Control =    0.033

Estimated Obs Based Global Index
(36 Month, normalised to March 2000)
  Control Case    =  114.550
  Test Case       =  114.645
  Test - Control =    0.095 ( 0.083 %)
```

Table 3. Verification of ERS-2 AMI addition against OBSERVATIONS.
Green--> Better; Red--> Worse; White--> Neutral

Parameter Details				No of Values	Control Data			Test Data			Differences		
Area	Field Code	Fc Range	Wt	12Z	Fc RMS	Per RMS	Wted Skill	Fc RMS	Per RMS	Wted Skill	Fc RMS Diff (%)	Skill Diff	UnWted Diff
NH	PMSL	T+24	10	30	0.957	3.711	9.335	0.957	3.701	9.331	0.04	0.00	0.00
NH	PMSL	T+48	8	29	1.502	5.285	7.354	1.496	5.274	7.356	-0.36	0.00	0.00
NH	PMSL	T+72	6	28	2.132	5.996	5.241	2.118	5.986	5.249	-0.68	0.01	0.00
NH	PMSL	T+96	4	27	2.943	6.394	3.152	2.940	6.382	3.151	-0.11	0.00	0.00
NH	PMSL	T+120	4	26	3.758	6.701	2.742	3.783	6.687	2.720	0.68	-0.02	-0.01
NH	H500	T+24	6	30	8.328	39.400	5.732	8.311	39.376	5.733	-0.21	0.00	0.00
NH	H500	T+48	4	29	14.129	59.113	3.771	14.041	59.083	3.774	-0.63	0.00	0.00
NH	H500	T+72	2	28	21.650	69.155	1.804	21.440	69.124	1.808	-0.97	0.00	0.00
NH	W250	T+24	12	30	3.991	15.213	11.174	3.985	15.216	11.177	-0.17	0.00	0.00
Trop	W850	T+24	5	30	1.984	3.602	3.483	1.982	3.602	3.486	-0.10	0.00	0.00
Trop	W850	T+48	3	29	2.710	4.828	2.055	2.709	4.825	2.054	-0.04	0.00	0.00
Trop	W850	T+72	2	28	3.207	5.162	1.228	3.208	5.158	1.226	0.02	0.00	0.00
Trop	W250	T+24	6	30	3.522	6.821	4.400	3.534	6.821	4.390	0.33	-0.01	0.00
SH	PMSL	T+24	5	30	1.460	8.721	4.860	1.465	8.716	4.859	0.31	0.00	0.00
SH	PMSL	T+48	4	29	2.558	11.920	3.816	2.559	11.914	3.815	0.06	0.00	0.00
SH	PMSL	T+72	3	28	3.783	13.390	2.761	3.758	13.384	2.763	-0.65	0.00	0.00
SH	PMSL	T+96	2	27	5.225	13.729	1.710	5.186	13.722	1.714	-0.74	0.00	0.00
SH	PMSL	T+120	2	26	6.787	13.655	1.506	6.756	13.647	1.510	-0.45	0.00	0.00
SH	H500	T+24	3	30	12.905	91.513	2.940	12.891	91.474	2.940	-0.10	0.00	0.00
SH	H500	T+48	2	29	23.835	129.118	1.932	23.826	129.074	1.932	-0.04	0.00	0.00
SH	H500	T+72	1	28	36.469	145.855	0.937	36.324	145.808	0.938	-0.40	0.00	0.00
SH	W250	T+24	6	30	4.101	21.608	5.784	4.093	21.599	5.784	-0.19	0.00	0.00

```
Total Weighted Mean Skill (total weight = 100)
  Control Case    =   87.719
  Test Case       =   87.712
  Test - Control =   -0.007

Estimated Analysis Based Global Index
(36 Month, normalised to March 2000)
  Control Case    =  121.808
  Test Case       =  121.775
  Test - Control =   -0.034 (-0.028 %)
```

4. Conclusions and recommendations.

The conclusions of this document are:

- The introduction of ERS-2 AMI data into the global model had a neutral impact based on results from a 1-season N216 4D-Var trial
- Long term monitoring of ERS-2 AMI shows that the instrument is accurate and stable enough for use in NWP
- ERS-2 AMI data coverage is limited but complementary to that of the SEAWINDS instrument
- With SEAWINDS having a limited future and ASCAT yet to be launched, the ERS-2 AMI instrument will provide some added resilience to the observing system
- The presence of two scatterometers in the suite did not cause any upstream problems, which is encouraging news as far as future ASCAT implementation is concerned.
- There is negligible additional computer costs involved in assimilating the two scatterometers

Based on recent monitoring and trial evidence it is recommended that:

- ERS-2 AMI data be reintroduced into the Met Office global model
- Local monitoring be performed in SA to track the future quality of ERS-2 AMI data

(MetDB merge-back, add to Tivoli and NWP SAF monitoring website)

5. Acknowledgements.

Thanks must go to Brett Candy for advice and expertise on the ERS-2 AMI Scatwind code and to Mary Forsythe for general trialing advice.

6. Reference.

Candy, B. and Offiler, D., 'OSDP8: Scatterometer Processing Description', Internal Report, July 2002.

Annex 1. Glossary and acronyms.

AMI	Active Microwave Instrument
ASCAT	Advanced SCATterometer
BUFR	Binary Universal Form for the Representation of meteorological data
C-band	Microwave band of the electromagnetic spectrum around 5 GHz
dB	decibel
DCP	Data Collection Platform
DWD	Deutscher Wetterdienst
ECMWF	European Centre for Medium-Range Weather Forecasts
EPS	EUMETSAT Polar System
ERS	European Remote-Sensing satellite
ERSURA	European Remote-Sensing satellite Radar Altimeter
ESA	European Space Agency
ESOC	European Space Operations Centre (an ESA establishment located in Darmstadt, Germany)
ESRIN	European Space Research Institute (ESA)
ESTEC	European Space Research and Technology Centre (an ESA establishment in the Netherlands)
EUMETSAT	The European Organisation for the Exploitation of Meteorological Satellites
GHz	Giga-Hertz
G/S	Ground Segment
GTS	Global Telecommunication System (of the WMO)
IFREMER	Institut Francais de Recherche pour l'Exploitation de la Mer
KNMI	Royal Netherlands Meteorological Institute
ku-band	Microwave band of the electromagnetic spectrum around 14 GHz
LAM	Local Area Model
LEO	Low Earth Orbit
LEOP	Launch and Early Orbit Phase
Metop	Meteorological Operational polar satellites of EUMETSAT
MLE	Maximum Likelihood Estimation
NASA	National Aeronautics and Space Administration (of the USA)
NESDIS	National Environmental Satellite Data and Information Service (of NOAA)
NPOESS	National Polar-orbiting Operational Environmental Satellite System (of the USA)
NSCAT	NASA Scatterometer
NWP	Numerical Weather Prediction
OPS	Observation Processing System
OSI	Ocean and Sea Ice SAF (see also SAF)
PGS	Primary Ground Station
POES	Polar-orbiting Operational Environmental Satellite (USA)
RFI	Radio Frequency Interference
RX	Receiver
QC	Quality Control
QuikSCAT	Quick SCATterometer
RA	Radar Altimeter
RMS	Root Mean Square
SAF	Satellite Application Facility
SAR	Synthetic Aperture Radar
SCAT	Scatterometer (satellite radar measuring winds over the oceans)
SFE	Scatterometer Front End
SSM/I	Special Sensor Microwave/Imager
SWI	Soil Wetness Index
TAO	Tropical Atmosphere-Ocean array of moored buoys in the Pacific
TOA	Top Of the Atmosphere
TX	Transmistter
UTC	Universal Time Coordinated
VAR/Var	Variational Assimilation System
WMO	World Meteorological Organization
X-Band	Frequency Band 6,2 - 10,9 GHz