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Royal Netherlands
Meteorological Institute
*Ministry of Infrastructure and the
Environment*

The Virtual Scatterometer Constellation and its Exploitation in User Applications

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Leader active sensing, R&D satellites (RDSW),
KNMI, the Netherlands

EUMETSAT Ocean and Sea Ice SAF

EU Copernicus Marine Service Wind TAC

with

contributions from many . . .



Golden age of Scatterometry (WMO OSCAR)



Instrument	NRT?	Relevance	Satellite	Orbit	DLR	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
WindRAD		1 - primary	FY-3E	05:40 desc		X	X	X	X	X	X								
WindRAD		1 - primary	FY-3J	05:00 desc							X	X	X	X	X	X	X	X	X
ASCAT	Yes	2 - very high	Metop-B	09:31 desc	50	X	X	X											
ASCAT	Yes	2 - very high	Metop-C	09:31 desc	85	X	X	X	X	X	X								
SCA (Scatterometer)		2 - very high	Metop-SG-B1	09:30 desc					X	X	X	X	X	X	X	X			
SCA (Scatterometer)		2 - very high	Metop-SG-B2	09:30 desc												X	X	X	X
C-SCAT ⚠		2 - very high	CFOSAT	07:00 desc		X	X												
HSCAT		2 - very high	HY-2B	06:00 desc	273	X	X												
HSCAT		2 - very high	HY-2D	66 °		X	X	X	X	X									
HSCAT		2 - very high	HY-2E	06:00 desc				X	X	X	X	X							
HSCAT		2 - very high	HY-2C	66 °		X	X	X	X										
HSCAT		2 - very high	HY-2F	66 °					X	X	X	X	X						
OSCAT-3		2 - very high	OceanSat-3 (EOS-06)	12:00 desc		X	X	X	X	X	X	X	X	X					

Source: <https://space.oscar.wmo.int/gapanalyses?mission=12>

Past C-band missions :

ERS-1,2/ESCAT 10:30 desc. 1992-1996, 1995-2000
 MetOp-A/ASCAT 9:30 desc. 2007-2021

Past Ku-band missions :

SeaWinds/QuikScat 6:00 desc. 1999-2009
 RapidScat/ISS 52 * 2014-2016
 OceanSat-2/OSCAT-1 0:00 desc. 2009-2014
 ScatSat-1/OSCAT-2 8:45 desc. 2016-2021

- Prepare ourselves for many scatterometers 😊
- Exploit for weather, ocean and climate applications

Motivation / Potential

- Scatterometer winds were introduced and represented at the IWWG meetings since 1996 (Ascona meeting)
- OSW side meetings were held at several IWWG meetings with representatives of the NWP community
- Several topics need further attention beyond CEOS and IOVWST, such as:
 - **Intercalibration** of wind products for Climate Data Records and operational user convenience
 - An **in-situ wind speed reference** for high and extreme winds
 - Methods for the elimination of model biases in **NWP data assimilation** (local VARBC)
 - Improved spatial NWP wind assimilation methods; assimilate unique wind products
 - QC optimization for NWP, Ku-band rain
 - Open high-level wind services and **global timeliness** of the virtual constellation
 - Open data comparisons and open software to share in the community
 - Exploit scatterometer wind stress measurements for improved **atmosphere-ocean coupling**
 - Development of **coastal winds** for all scatterometers
- The OSW TG facilitates an **open and shared environment** to address above points for the general benefit of the meteorological/ocean community



To be considered by CGMS from OSW TG

- For improved satellite wind speed calibration, collaboration on WMO level with in-situ experts and with dropsonde providers is recommended in order to better comprehend in-situ measurement data and their accuracy in extreme conditions, which is of large societal relevance;
- Encouragement and support from satellite agencies would accelerate the effective use of the OSW that they produce in NWP with potentially large effect on forecast quality of the extending virtual scatterometer constellation;
- To define an official international operational framework to ensure timely and valuable high-resolution SAR acquisitions of Tropical Cyclones (cf. WMO IWTC-10).



F2F IOVWST

- Overview of the constellation
- Combining scatterometers to improve (inter)calibration and QC
- Improvements in spatial processing at extremes, coastal
- Scatterometer data assimilation
- Ocean forcing using scatterometers
- Novel missions and science

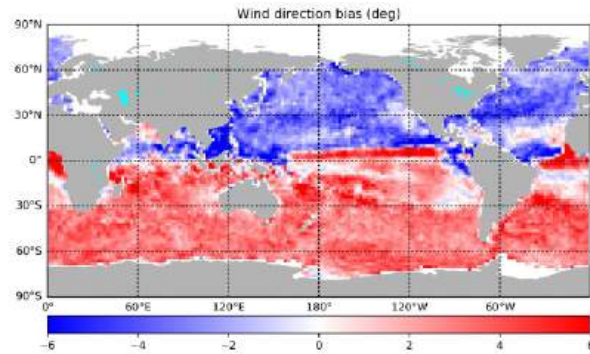
<https://osi-saf.eumetsat.int/community/stories/international-ocean-vector-winds-science-team-meeting-2023>



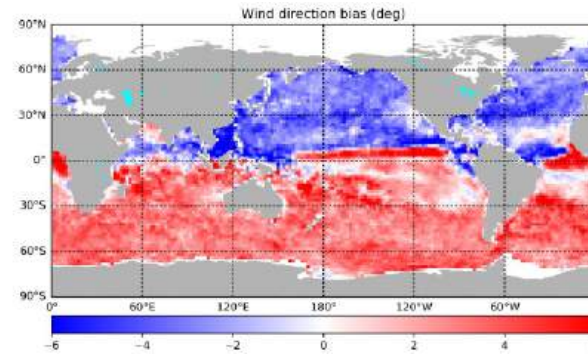
Wind **direction** biases of SCA - NWP

From 5 different scatterometers:

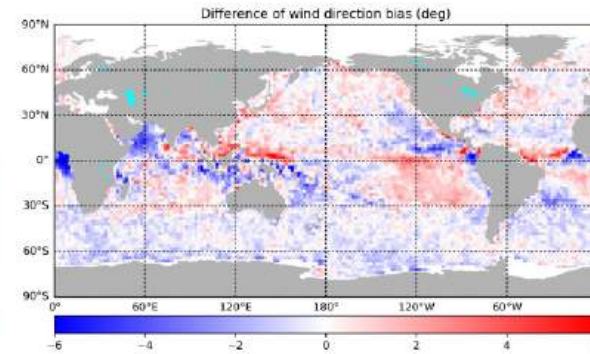
➤ Pattern could be diurnal cycle error



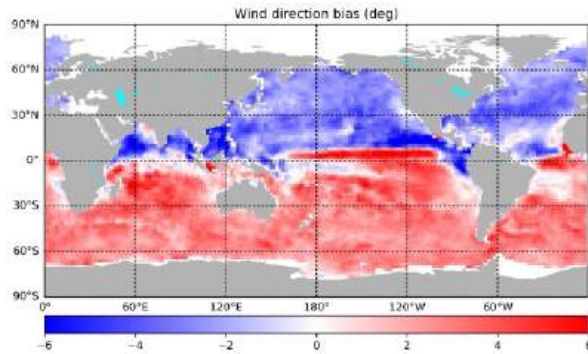
ASCAT-B NRT



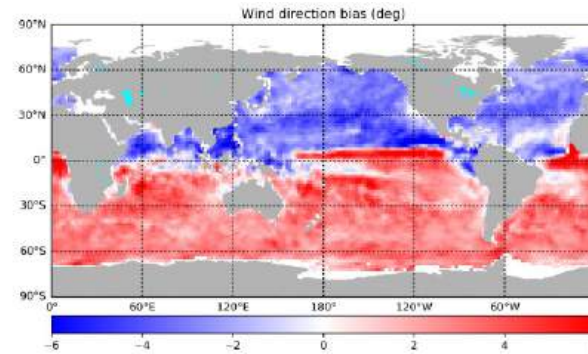
ASCAT-C NRT



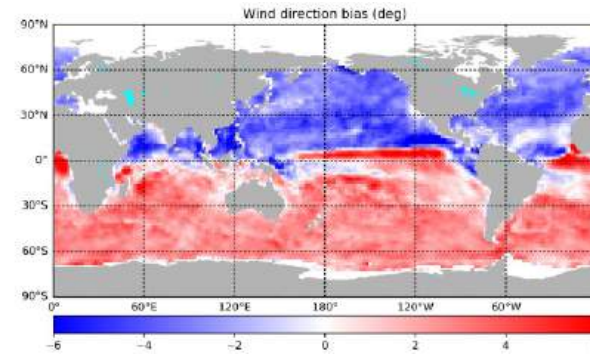
ASCAT-B/NRT – HSCAT-B/Rep02



HSCAT-B Rep02



HSCAT-C Rep02



HSCAT-D Rep02

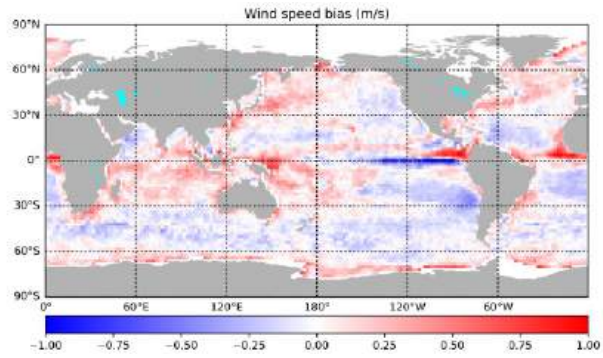
➤ What happens when you push ocean water in the wrong direction in digital Earth models ?

➤ Thanks to Zhixiong Wang, NUIST

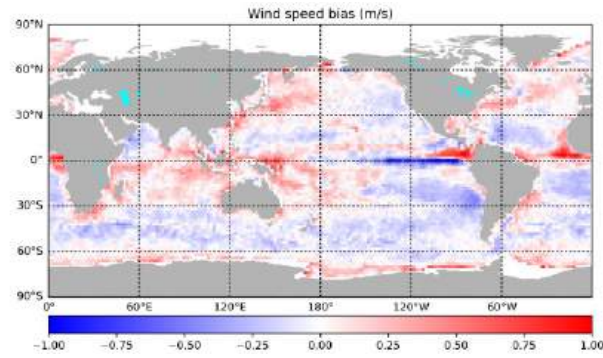
Wind speed biases of SCA - NWP

From 5 different scatterometers:

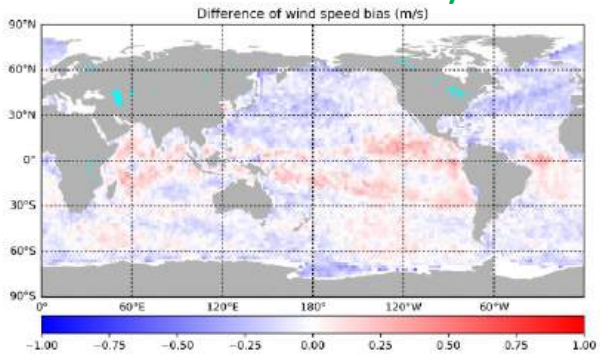
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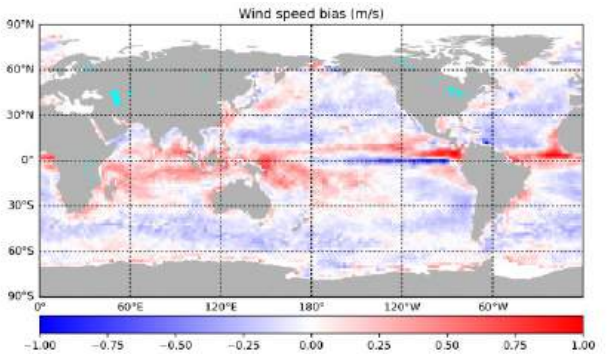
ASCAT-B NRT



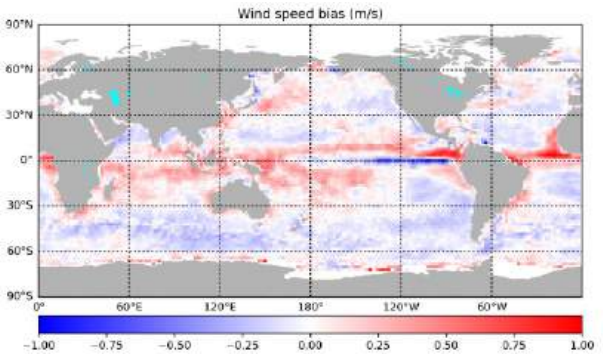
ASCAT-C NRT



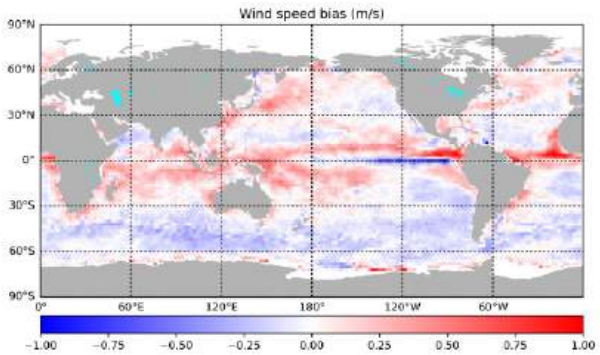
ASCAT-B/NRT – HSCAT-B/Rep02



HSCAT-B Rep02



HSCAT-C Rep02



HSCAT-D Rep02

➤ What happens when you push ocean water wrongly in digital Earth models ?

➤ Thanks to Zhixiong Wang, NUIST

BACKGROUND INFORMATION

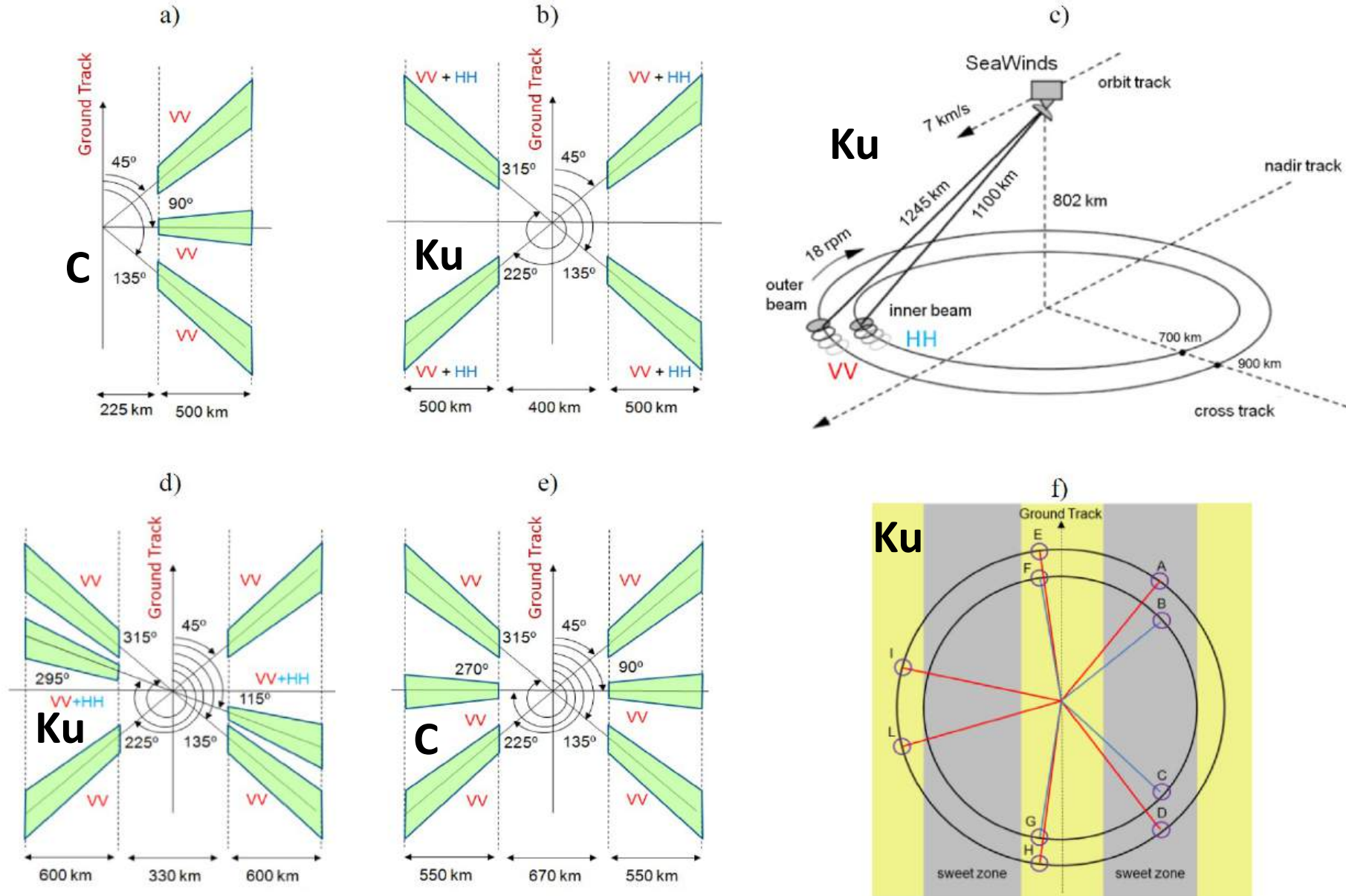


Fig. 1.4 Sketch of the microwave illumination patterns of: a) AMI (ERS-1/2); b) SASS (SeaSat-A); c) and f) SeaWinds, Oceansat-2 SCAT and HY-2A; d) NSCAT; e) MetOp ASCAT-A and B. The case a), b), d) and e) correspond to a fan beam geometry whereas c) and f) correspond to a pencil beam geometry.





Stress-equivalent wind

- Radiometers/scatterometers measure ocean roughness
- Ocean roughness consists in small (cm) waves generated by air impact and subsequent wave breaking processes; depends on **gravity, water mass density, surface tension s** , and e.m. sea properties (assumed constant)
- Air-sea momentum exchange is described by $\tau = \rho_{air} u_* \mathbf{u}_*$, the stress vector; depends on air mass density ρ_{air} , friction velocity vector \mathbf{u}_*
- Surface layer winds (e.g., \mathbf{u}_{10}) depend on \mathbf{u}_* , atmospheric stability, surface roughness and the presence of ocean currents
- Equivalent neutral winds, \mathbf{u}_{10N} , depend only on \mathbf{u}_* , surface roughness and the presence of ocean currents and is currently used for backscatter geophysical model functions (GMFs)
- $\mathbf{u}_{10S} = \sqrt{\rho_{air}} \cdot \mathbf{u}_{10N} / \sqrt{\rho_0}$ is now used to be a better input for backscatter GMFs (stress-equivalent wind)
- This prevents regional biases against local wind references

Current CGMS OSW Task Group

- Ad Stoffelen (KNMI, lead)
- Fangli Du (CMA)
- Jian Shang(CMA)
- Régis Borde(EUMETSAT, **IWWG**)
- Stefanie Linow (EUMETSAT)
- Mark Bourassa (FSU, **IOVWST**)
- Dave Halpern (**IOC**)
- Raj Kumar (ISRO, ret.)
- Ernesto Rodriguez (NASA)
- Svetla Hristova (NASA)
- Paul S Chang (NOAA, **CEOS VC**)
- Juhong Zou (NSOAS)
- Dong Xiaolong (NSSC, **CEOS WGCV MSSG**)
- Steve Wanzong (UW-Madison/SSEC/CIMSS, **IWWG**)
- Heikki Pohjola (**WMO**)

Instruments

- WindRad (CMA)
- HY2-B/C/D (NSOAS)
- ASCAT-A/B/C (EUMETSAT)
- CFOSAT (NSOAS/CNES)
- OceanSat-2/3, ScatSat (ISRO)
- NSCAT, QuikScat, RapidSCAT (NASA)
- ERS-1/2 (ESA)
- WindSat, SSMI, AMSR, MWI
- SAR (ERS, Envisat, S-1, RadarSat, . . .)
- (GNSS-R)
- (Altimeters)



Actionable CGMS members

- Current and prospective developers and operators of meteorological satellites
- WMO, because of its unique role as representative of the world meteorological data user community, and other programmes jointly supported by WMO and other international agencies
- Space agencies operating R&D satellites contributing to WMO programmes

CMA	China Meteorological Administration	1989
CNES	Centre National d'Etudes Spatiales	2004
CNSA	China National Space Administration	2006
ESA	The European Space Agency	2003
EUMETSAT	EUMETSAT	1987
IMD	India Meteorological Department	1979
IOC-UNESCO	Intergovernmental Oceanographic Commission - UNESCO	2001
ISRO	Indian Space Research Organisation	2015
JAXA	Japan Aerospace Exploration Agency	2003
JMA	Japan Meteorological Agency	1972
KMA	Korea Meteorological Administration	2005
NASA	National Aeronautics and Space Administration	2003
NOAA	National Oceanic and Atmospheric Administration	1972
ROSCOSMOS	Russian Federal Space Agency	2003
ROSHYDROMET	Russian Federal Service for Hydrometeorology and Environmental Monitoring	1973
WMO	World Meteorological Organization	1973

Observers

CSA	Canada Space Agency
ENV CAN	Environment Canada
GCOS	Global Climate Observing System
KARI	Korea Aerospace Research Institute
KIOST	Korea Ocean Research & Development Institute
SOA	State Oceanic Administration (National Satellite Ocean Application Service, NSOAS, under the Ministry of Natural Resources, MNR)