Investigating the October effect in VLF signals

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Background

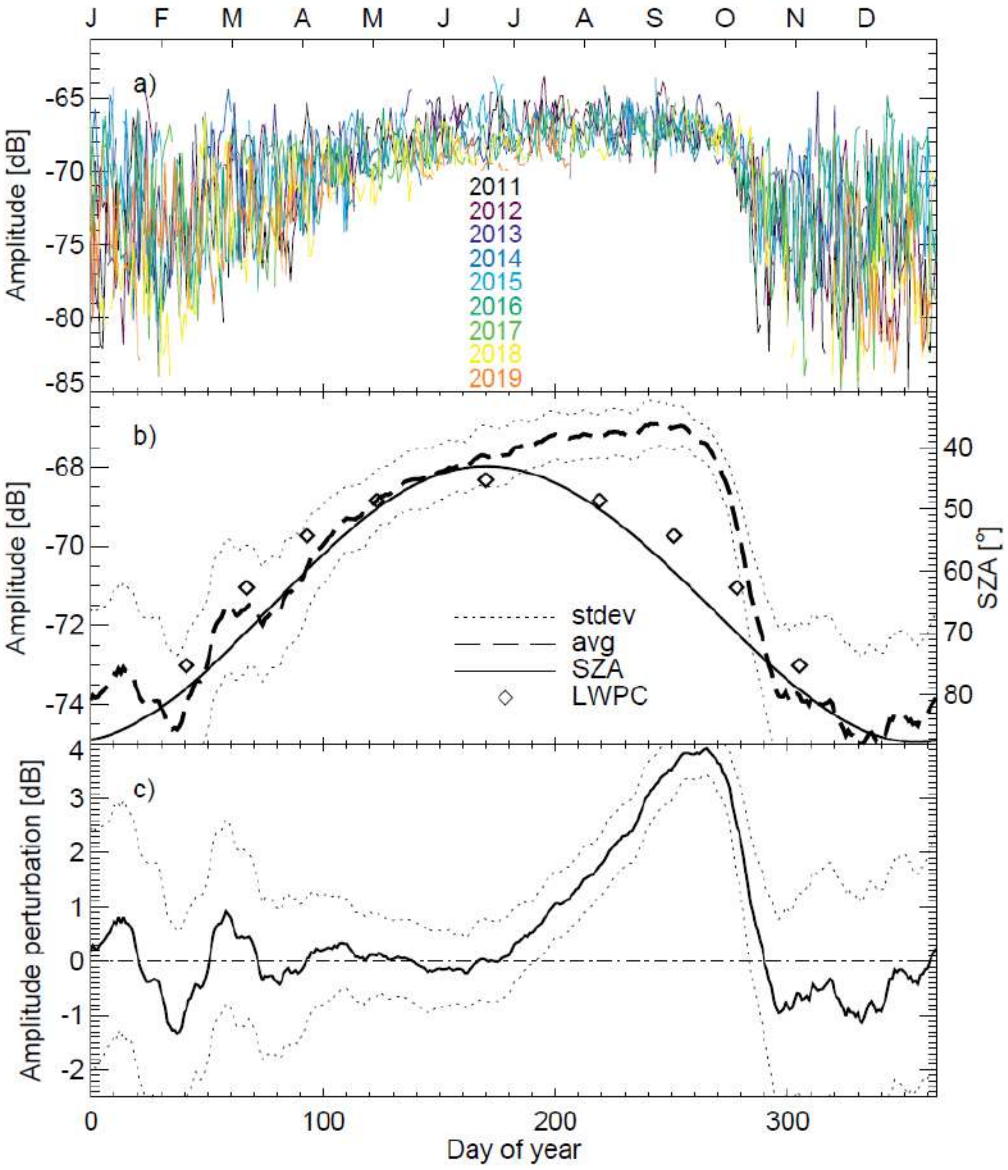
October-effect:
Sharp decrease of the signal amplitude in october
(Pancheva & Mukhtarov, 1996)

Fall-effect:
Divergence between the VLF signal amplitude and the solar zenith angle starting in late summer
(Macotela et al., 2021)

Motivation
→ Understanding the coupling processes of the mesosphere and lower ionosphere (D-layer)
→ Ensuring the reliability of VLF signals and therewith maintaining adequate performance up to HF systems

AMELIE
Analysis of the **Me**sosphere and **L**ower **I**onosphere fall **E**ffect

- Joint project with the University of Rostock / IAP Kühlungsborn
- Associates: Dr. Mark Clilverd (BAS)
  Prof. Martin Friedrich (TU Graz)
  Dr. Daniel Marsh (NCAR)
  Dr. Nicholas Pedatella (NCAR)
  Prof. Jean-Pierre Raulin (CRAAM)
- Other Data: Radar, MLS, VLF, Ionosondes, GOES, SDO
- Used Models: WACCM-D, WACCM-X, LWPC, FIRI



Macotela et al., 2021

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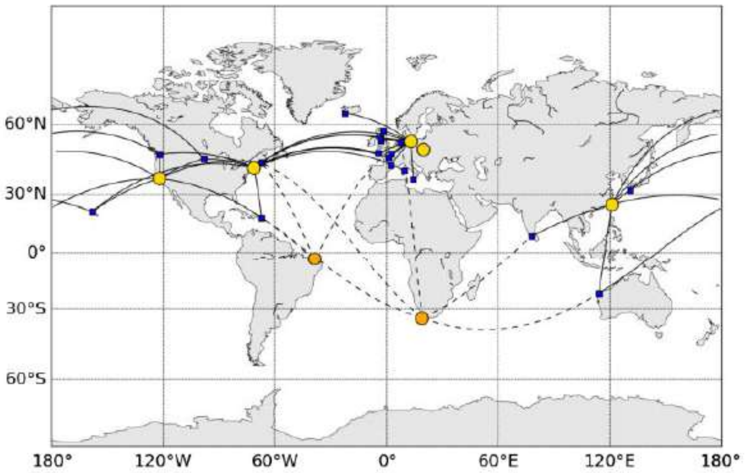
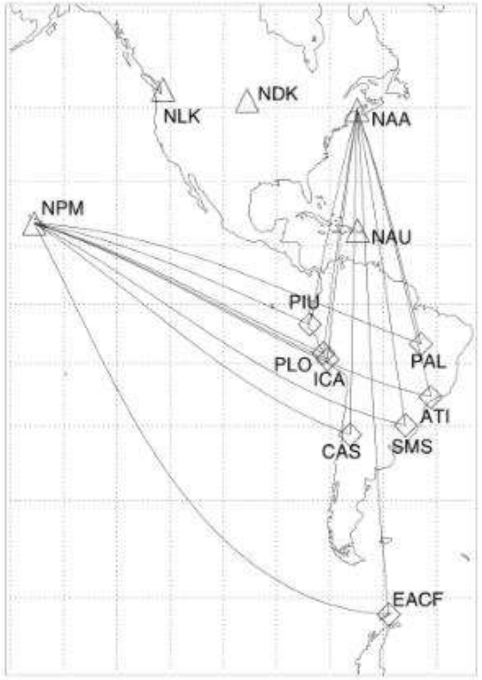
VLF networks

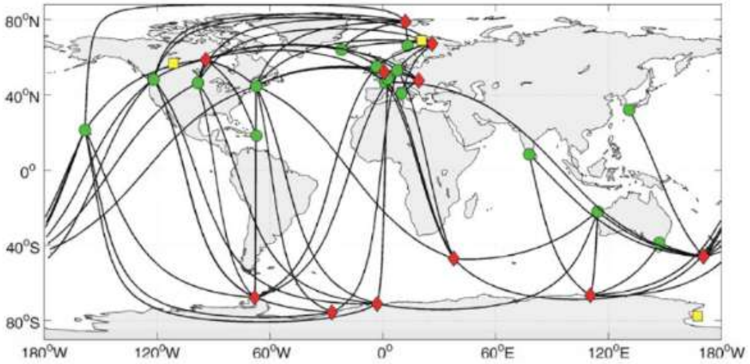
GIFDS



SAVNET



AARDDVARK



- **GIFDS**
  - Global Ionospheric Flare Detection System, since 2012
  - mainly located at Northern mid-latitudes with the main objective of real-time monitoring of solar flares

  → *Institute's own system (DLR-SO)*
- **AARDDVARK**
  - Antarctic-Arctic Radiation-belt (Dynamic) Deposition - VLF Atmospheric Research Konsortia, since 2005
  - at particularly high latitudes focusing on the investigation of whistler-induced electron precipitation, REPs, SPEs, ionisation of NOx by Lyman-α, and solar flares

  → *Collaboration partner: Mark Clilverd (BAS)*
- **SAVNET**
  - South American VLF Network
  - with the aim to uncover the South Atlantic Magnetic Anomaly

  → *Collaboration partner: Jean-Pierre Raulin (CRAAM)*

Instrumentation

VLF signals of Navy stations measured per second:

Amplitude Phase

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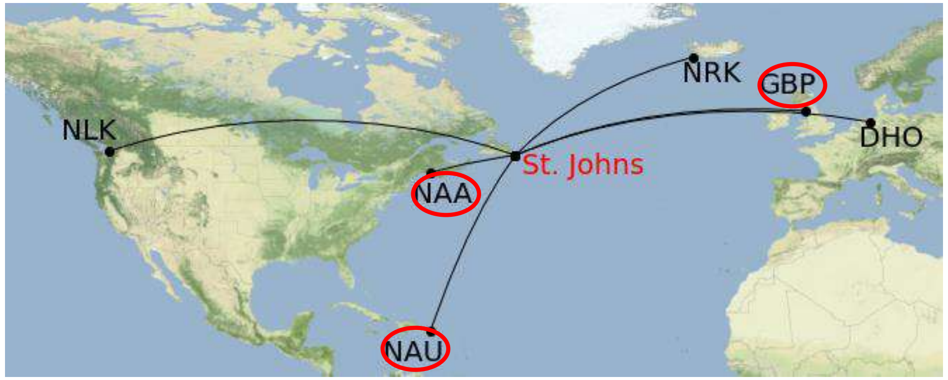
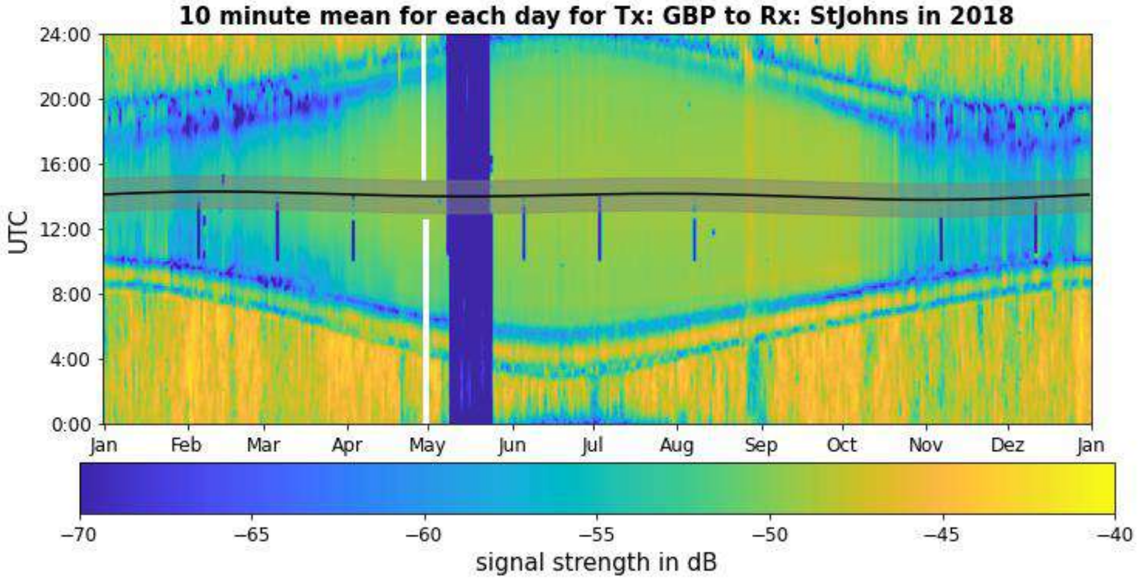
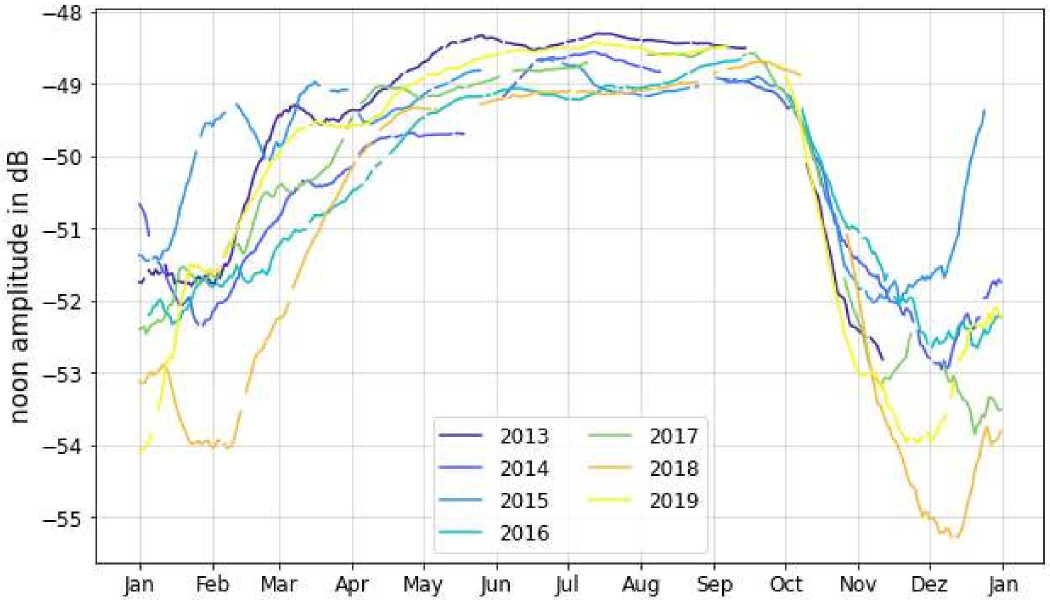
VLF measurements Case study



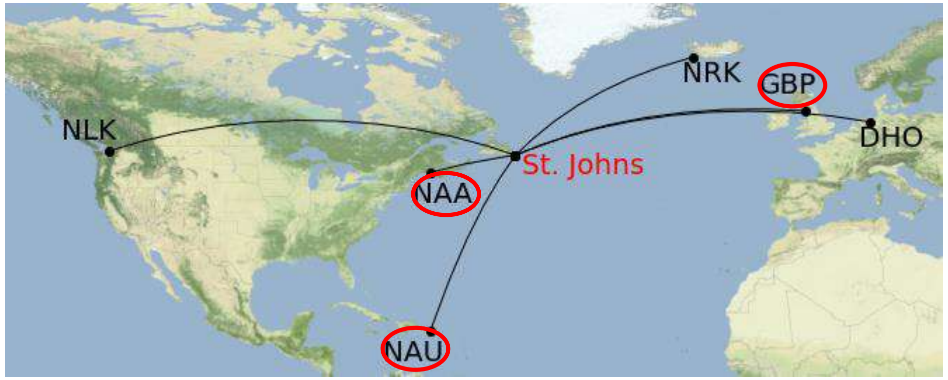
Systematic analysis of the october effect

- Comparison between high, mid and low latitudes:
    - High-latitude paths show a steeper and stronger decrease in fall than the low latitudes
    - High-latitude paths show a stronger asymmetry over the year
    - High-latitude paths form a plateau
- Comparisons over time for deriving delays, different longitudes, etc.
- Comparison of solar maximum and solar minimum:
    - stronger decrease during solar minimum than in the solar maximum





VLF measurements Case study



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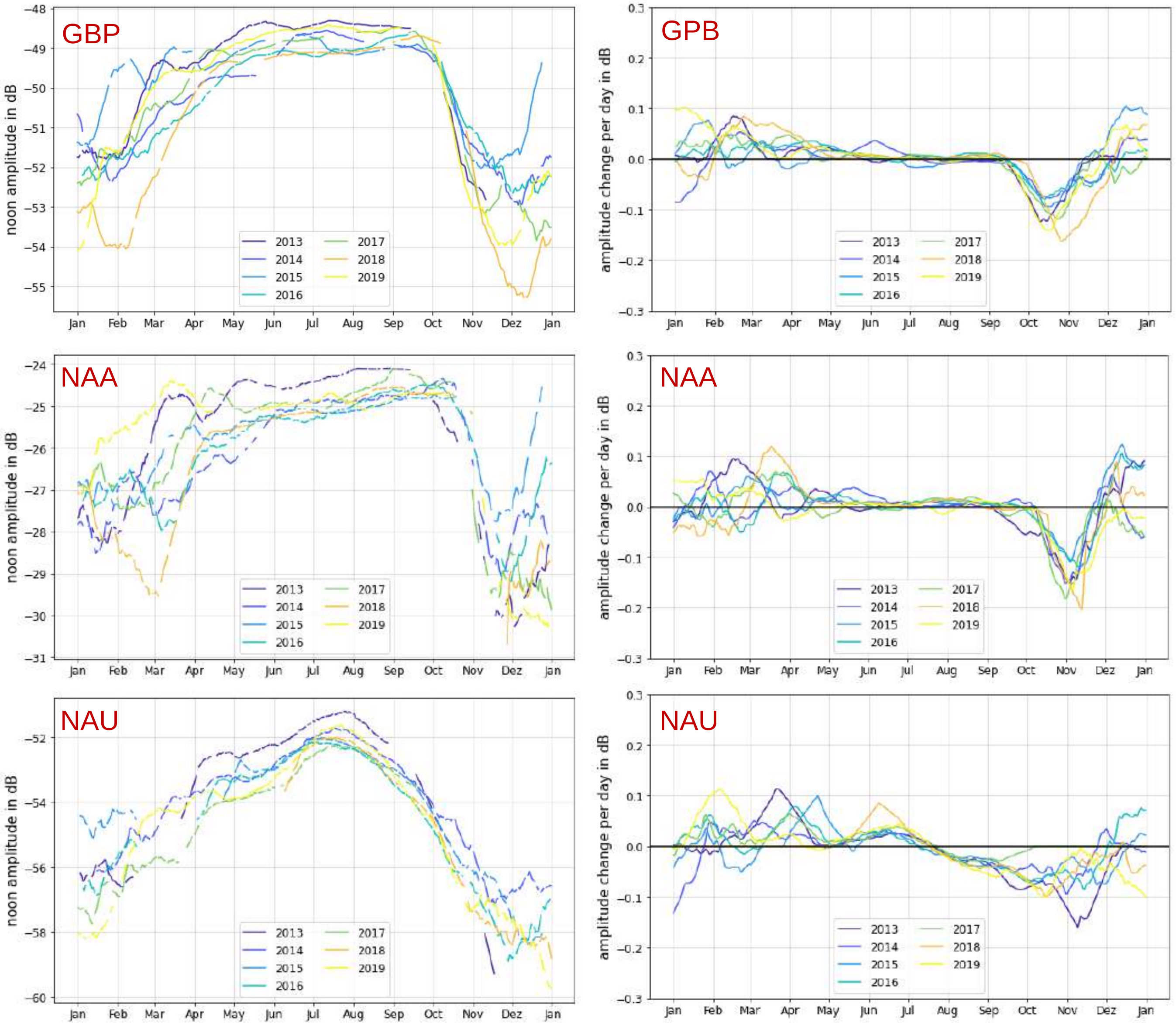

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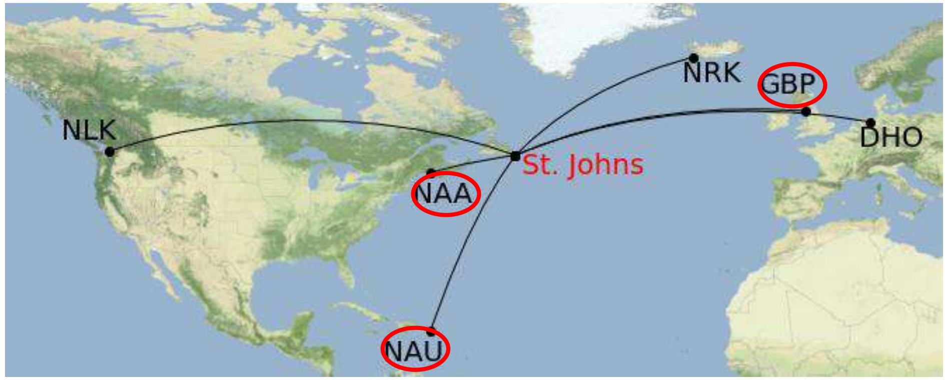
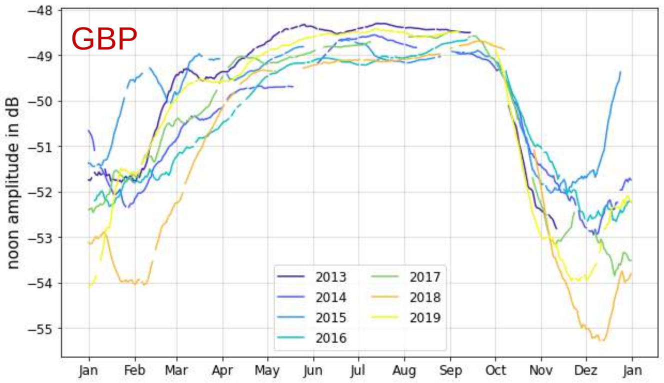
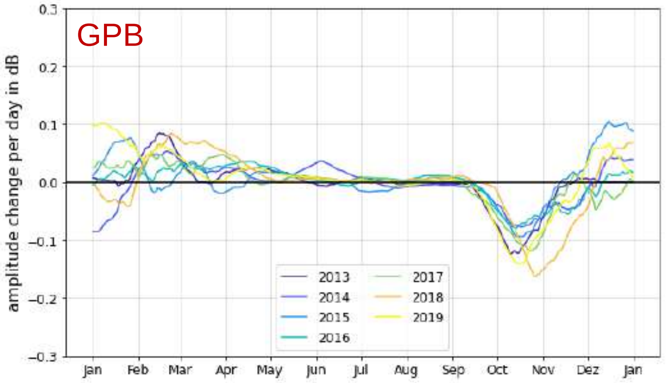
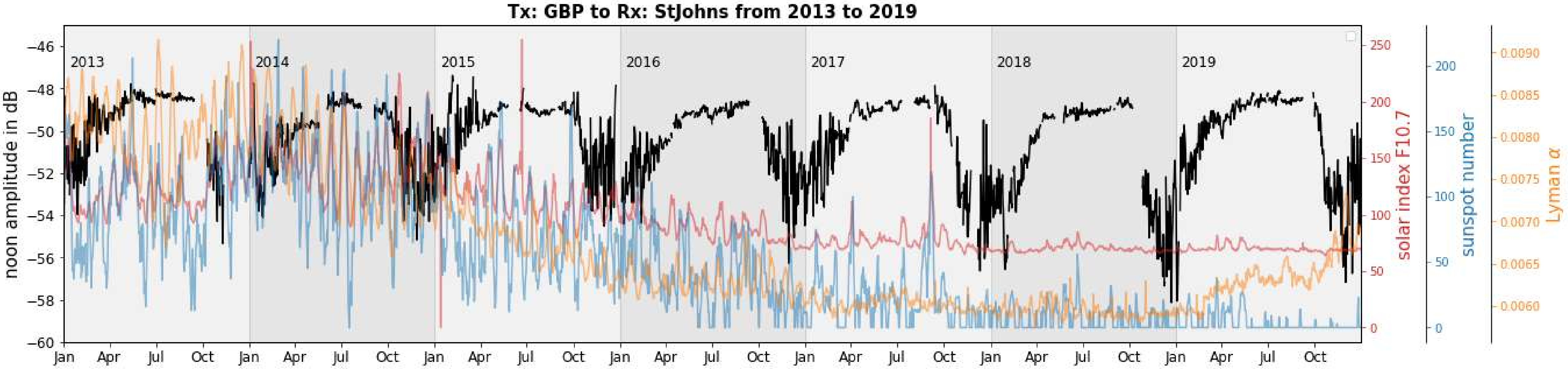








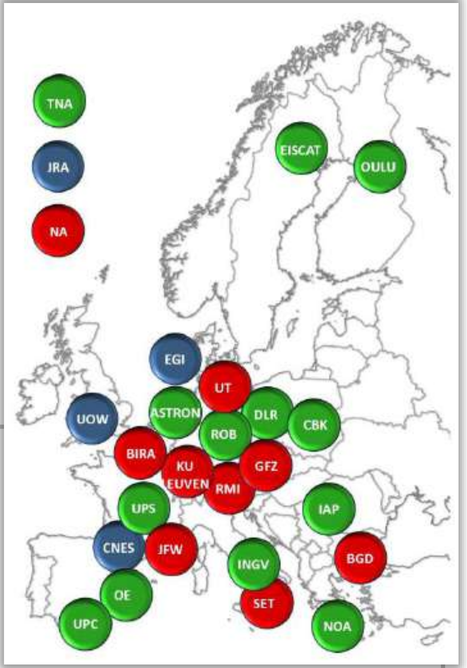
GIFDS data base Implementation

PITHIA-NRF
Plasmasphere **I**onosphere **Th**ermosphere **I**ntegrated Research Environment and **A**ccess services:
a **N**etwork of **R**esearch **F**acilities

- Aims at building a European distributed network that integrates observing facilities, data processing tools and prediction models dedicated to ionosphere, thermosphere and plasmasphere research
- Key national and regional research infrastructures such as EISCAT, LOFAR, Ionosondes and Digisondes, GNSS receivers, Doppler sounding systems, riometers, and VLF receivers, ensuring optimal use and joint development
- Is designed to provide organized access to experimental facilities, FAIR data, standardized data products, training and innovation services.
- PITHIA-NRF consortium involves 22 administrative partners and one third party scientific enterprise
- DLR provides 1 out of 12 nodes for data access/distribution with the IMPC: https://impc.dlr.de/

PITHIA-NRF Research Infrastructure

European Commission
Horizon 2020
European Union funding
for Research & Innovation



Receiver:
Name: Freq: Location:
Search

Transmitter:
Name: Freq: Location: US
Search

	site		station ▸		position ▸		location ▸	service ▸	notes	!!!
	network	affiliate	orientation	bands	lat [°]	lon [°]	country	maintenance		

	identity ▸		sender ▾					position ▸		location ▸	operation ▾				notes	!!!
	call sign	channel	frequency [Hz]	range	bandwidth	modulation	power [kW]	lat [°]	lon [°]	country	broadcaster	status	on air	maintenance		
☐	NML	25.2k	25200	VLF	0		0	46.365987	-98.335667	US	U.S. Navy	active	P	2T12P7h	▸	edit
☐	NPM	23.4k	23400	VLF		MSK		21.4202	-158.1511	US	U.S. Navy	active	P		▸	edit
☐	NPM	21.4k	21400	VLF	200	MSK		21.4202	-158.1511	US	U.S. Navy	active	P		▸	edit
☐	NLK	24.8k	24800	VLF	200		1200	48.203633	-121.916828	US	U.S. Navy	active	P		▸	edit
☐	WWVB	60k	60000	LF		PWM/PM(BPSK)/AM		40.678056	-105.046944	US	NIST	active	P		▸	edit
☐	NAA	24k	24000	VLF	200	MSK, FSK (F1B)	1800	44.6465	-67.2825	US	U.S. Navy	active	P		▸	edit

Search

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GIFDS data base Implementation

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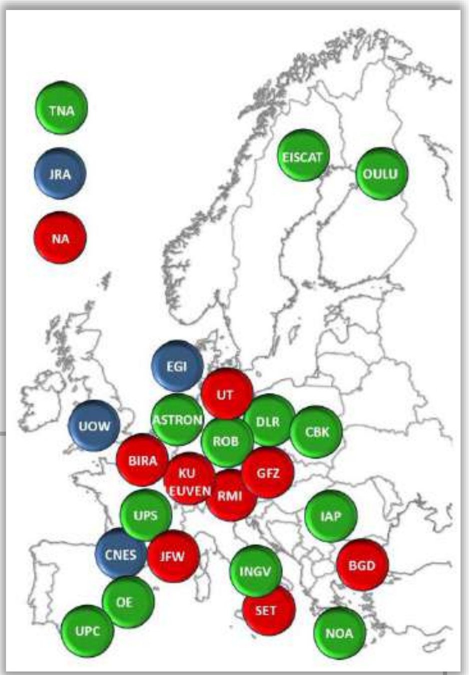

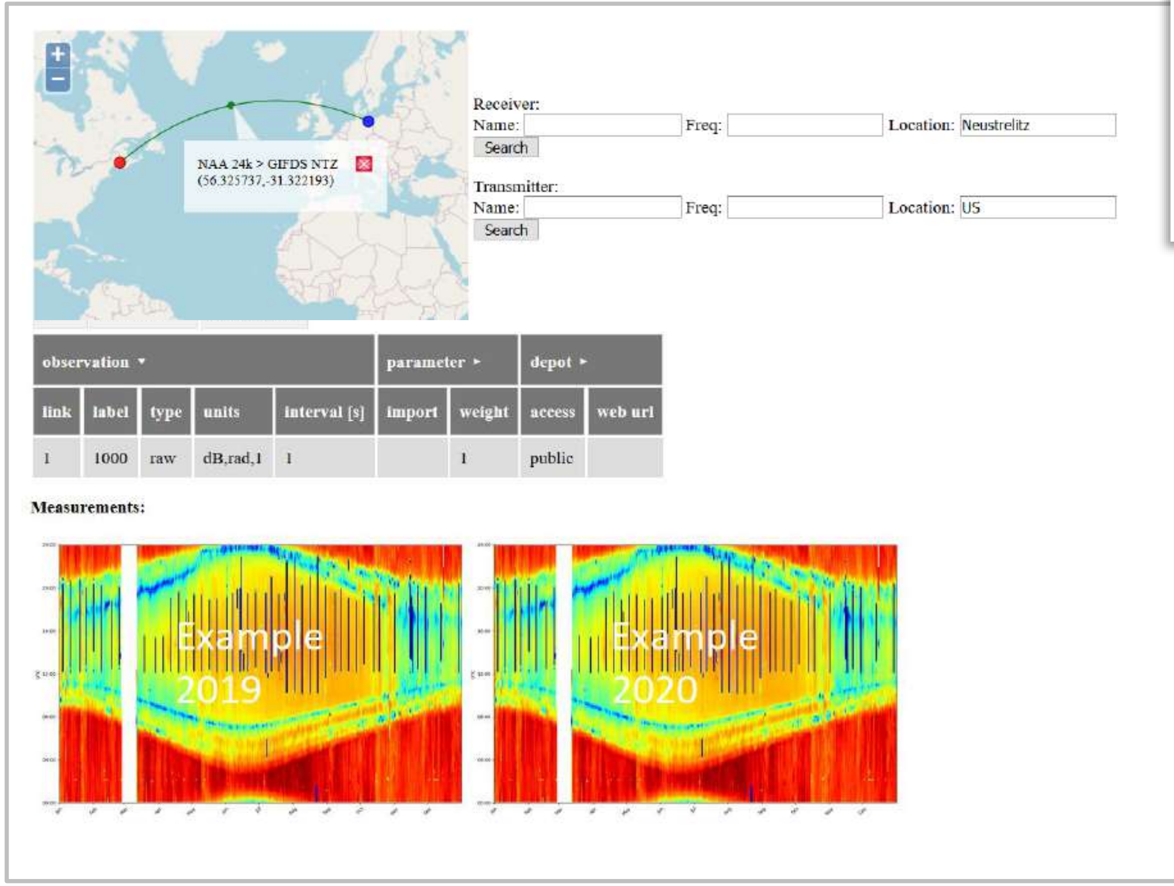

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Thank you!