



TONE

Troll Observasjonsnettverk

Status etter fjerde år av implementeringen

Christina A. Pedersen, NP, og Rune Storvold, NORCE



Observatorier



8 observatorier som samler inn lange tidsserier som beskriver jordsystemet.

Tjenester



En dronetjeneste som komplementerer datainnsamlingen fra observatoriene.

Datasystem



Et dataforvaltnings-system som tar vare på og tilgjengeliggjør dataene til alle brukere.

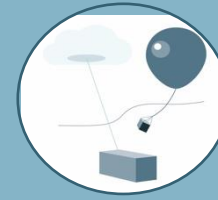


Ionosfæreobservatoriet

Kunnskap om romvær og sørlys

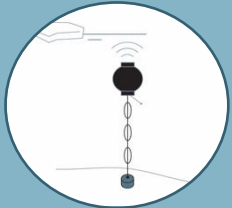


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Det integrerte skyobservatoriet

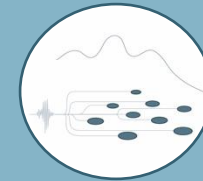
Egenskaper til skyer og aerosoler



Atmosfærekjemiobservatoriet

Transport og effekt:
forurensning på global skala

nilu

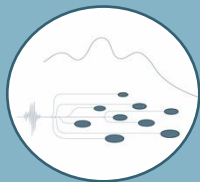


Infralyd array

Atmosfæredynamikk og vertikal kobling

NORSAR

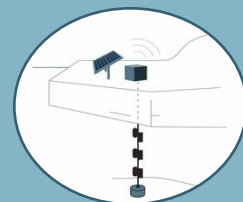




Seismisk array

Jordbevegelser fra seismiske kilder

NORSAR



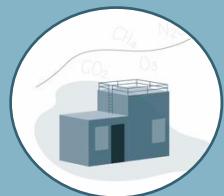
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British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Fimbulisen isbremobservatorie

Endringer i isbremdynamikk

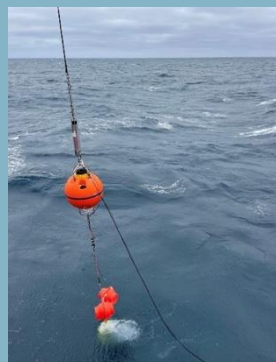


Multidisiplinært havriggobservatorium

Fysiske og biologiske prosesser i det marine systemet



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Sjøfuglobservatorium

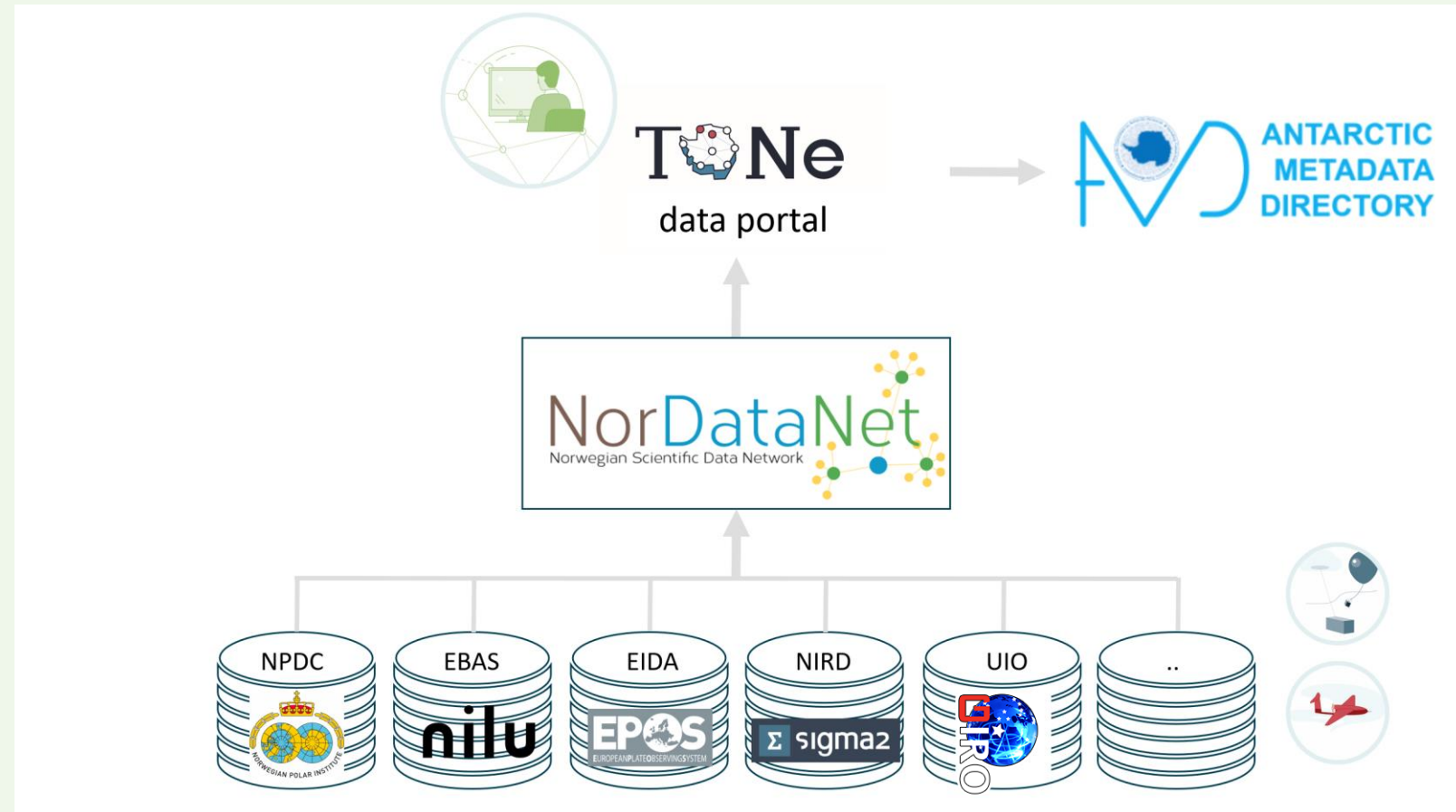
Tar pulsen på det marine miljøet i Sørishavet





Dataforvaltningssystem og TONE webportal

- Viktig prinsipp å utnytte alle data så godt som mulig
- Stort fokus på dataforvaltningen
- Ny TONE dataportal hos NP





Remotely Piloted Aircraft System

TONe Drone Services



Aircraft Specifications

Windracer Ultra 2 drone:

- Endurance: up to 800 km, 8 Hrs
- Payload capacity: 150 kg
- Broadband Satcom: Starlink
- Runway Requirements: 300 m



CW Fox X8

- Cruise speed: 50 kph
- Range: up to 20 km
- Payload capacity: 20 kg



CW Shark VTOL

- Cruise speed: 70 kph
- Range: 100 km
- Payload capacity: 2 kg

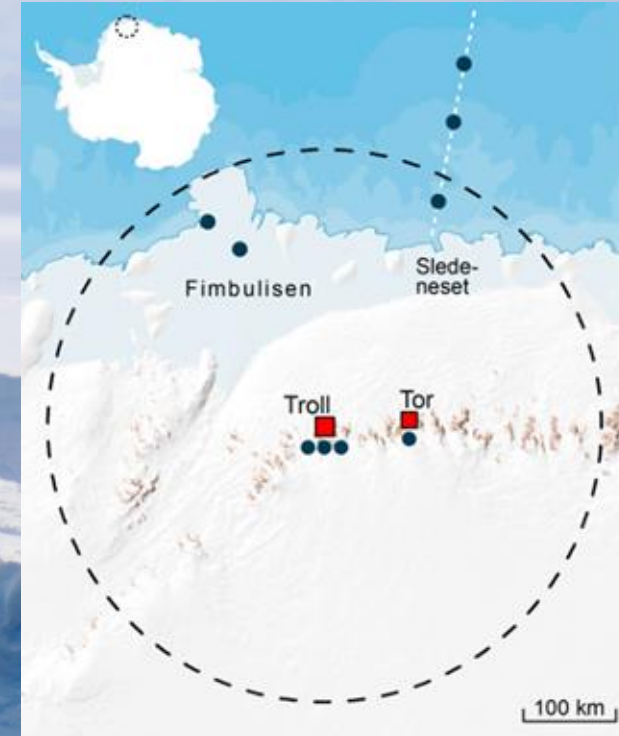
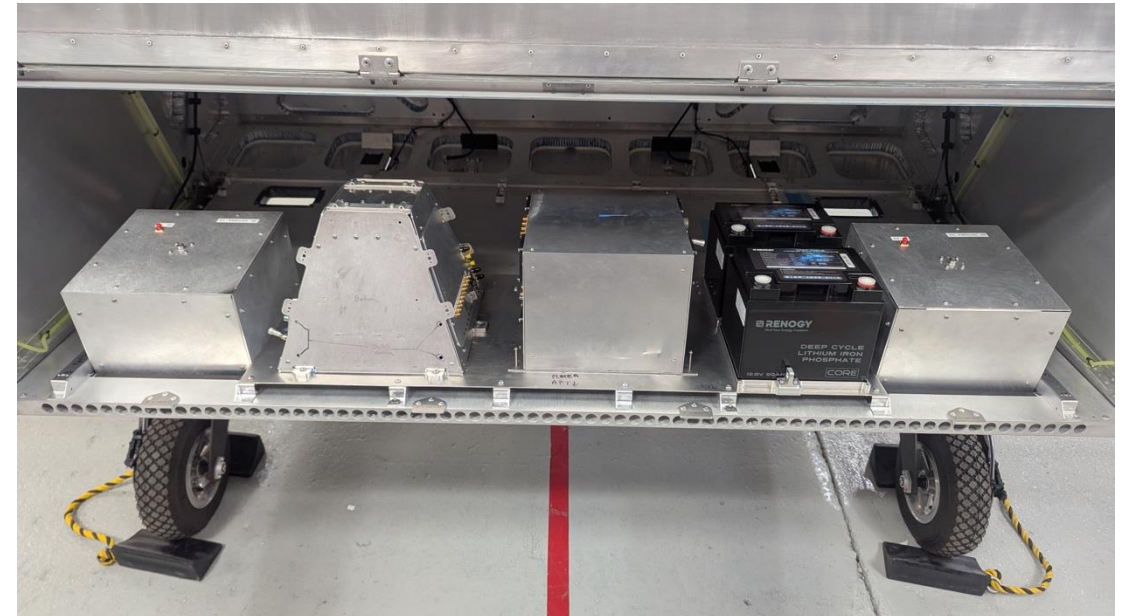


Photo: Carl Robinson - BAS

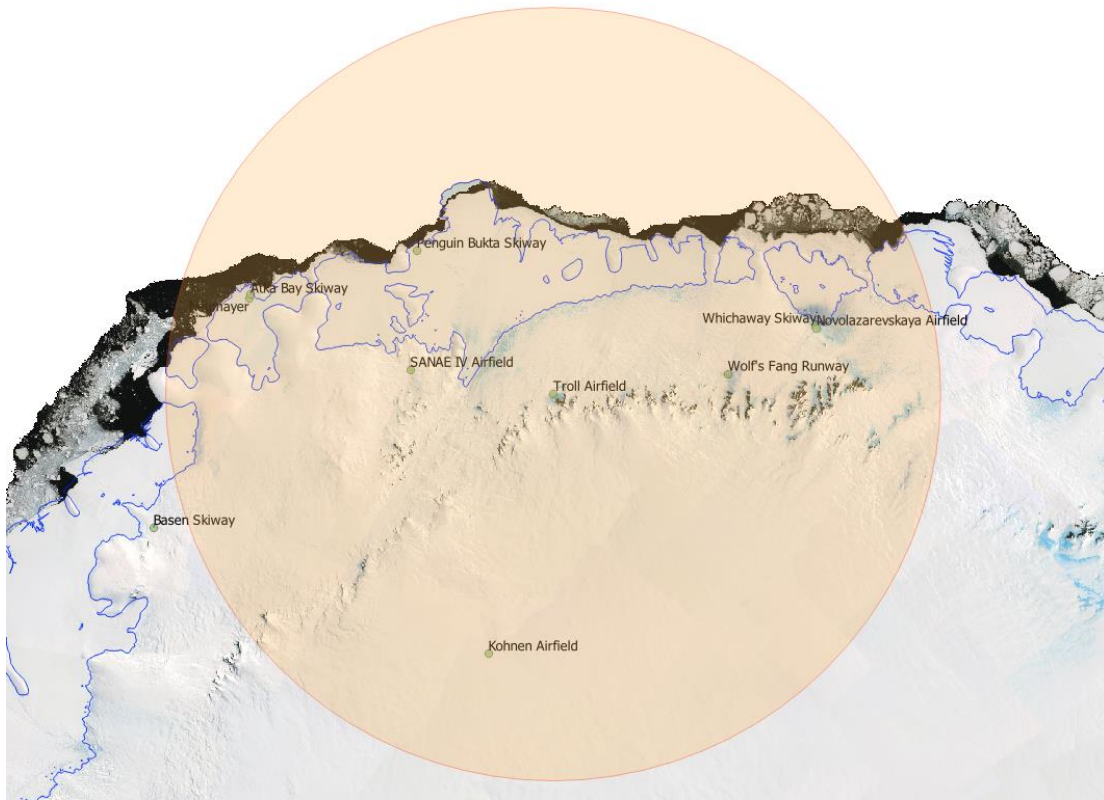
TONE-drone payload: Overview

- Met Pack - PTH - Temperature, Humidity and Pressure
- Hyperspectral Imager
 - Max resolution @ 700 m is 20 cm this gives a swath width 250 m
- High resolution cameras
 - Max resolution @ 350 m is 5 cm this gives a swath width of 1000 m
- UWB Radar 2-8 GHz, vert. resolution 5 cm
- VFH radar 67 MHz, 10 MHz bandwidth, vert. resolution 30 m





Troll Observing Network Drone Service



Cryosphere

- GHz radar 2-8GHZ– snow stratigraphy and precipitation distribution
- VHF radar 67MHz – bedrock depth

Atmosphere

- Basis sensorer for meteorologi
- Bredbånds strålings sensorer – energi balanse og skyegenskaper

Birds

- High-resolution RGB camera – Mapping bird colonies

Biomass and primary production

- Hyperspectral imager – Chlorophyll-A

Geology

- High-resolution camera – high-resolution 3D terrain models.

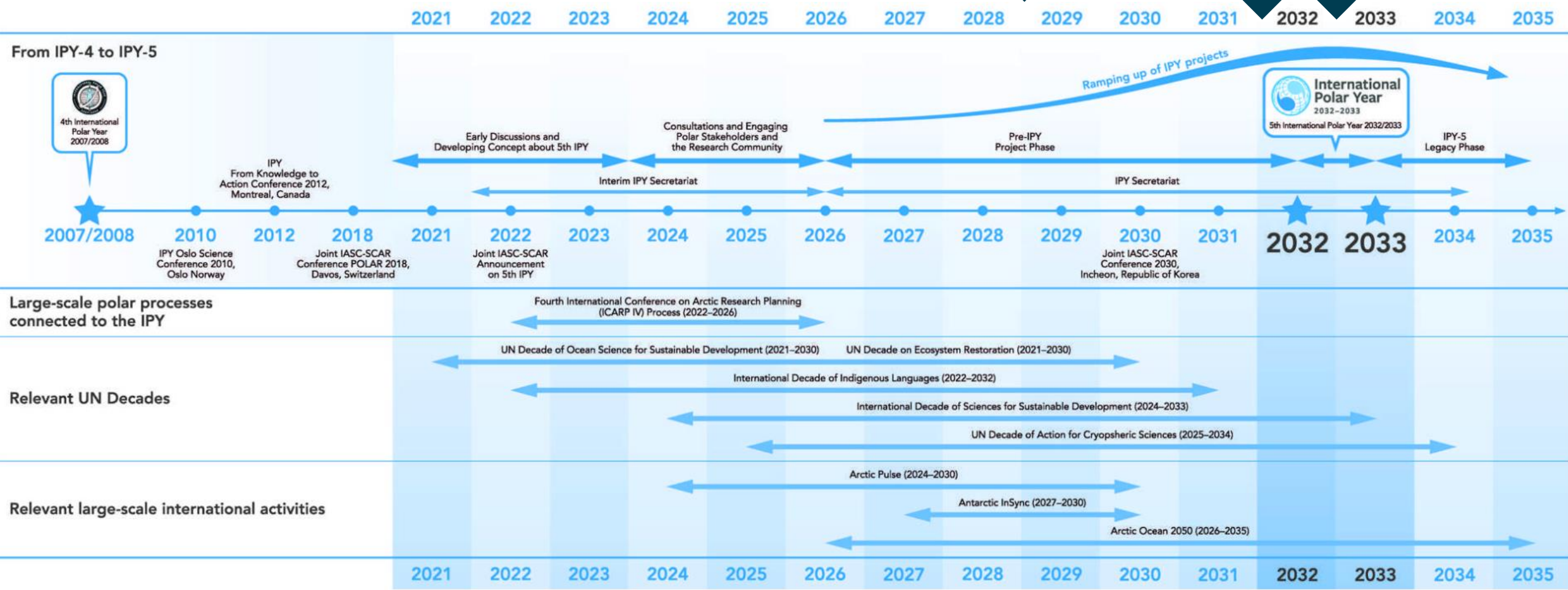
TONE drone prosjektsøknader

Project acronym	Project name	Name PI	Partner institutions	Disipline
Subrocks	Subglacial rocks between H.U. Sverdrupfjella and Mühlig-Hofmannfjella, Dronning Maud Land, Antarctica: Implications for ice dynamics and basal conditions.	Ø. Sunde	NP, NTNU, BAS, AWI	cryo, geo
TROMA	TONE drones' Marine Application (Austral summer 2026/27)	S. Moreau	NP, UiT, IC3, NORCE, NTNU, Uni Strathclyde	marine, cryo, oceano, tech
SCAN	Seabird Census by Aerial Navigation	S. Descamps	NP, WHOI (US), CNRS (France)	marine bio, terr bio
ICO	TONE-ICO drone application	S. Hudson	NP, ESR (Seattle), Uni Leeds, WSU	atmos, cryo, other
TopoKartDML	Topografisk kartlegging i Dronning Maud Land.	H. F Aas	NP	tech and other
JoSAS	Jotulstraumen Subglacial Access Survey	T. Hattermann	NP, UiT, BAS, NORCE, iC3, TONE	marine bio, cryo, oceano, other
Snoocean	Vidisen snø & sjø (snow & ocean)	G. Moholdt	NP, NORCE	cryo
GoFlow	Go with the Flow: Radar Surveys of Subglacial Meltwater Flow Paths	J. van Oostveen	NP. I dialog med samarbeidspartnere fra NP, IC3, University of Waterloo, Canada	cryo, geo

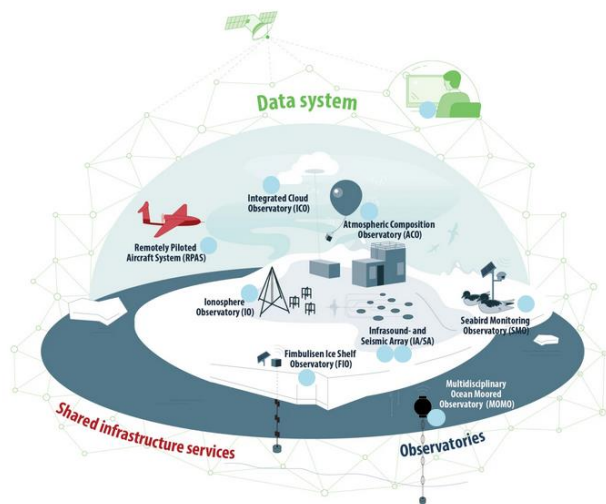
PILOT KAMPANJE 2026/27

KAMPANJE 2028/29

IPY KAMPANJER 2031/32, 2032/33



TONE website: <https://npolar.no/tone/>



PERSPECTIVE

The Troll Observing Network (TONE): plugging observation holes in Dronning Maud Land, Antarctica

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Abstract

Understanding how Antarctica is changing and how these changes influence the rest of the Earth is fundamental to the future robustness of human society. Strengthening our understanding of these changes and their implications requires dedicated, sustained and coordinated observations of key Antarctic indicators. The Troll Observing Network (TONE), now under development, is Norway's contribution to the global need for sustained, coordinated, complementary and societally relevant observations from Antarctica. When fully implemented within the coming three years, TONE will be a state-of-the-art, multi-platform, multi-disciplinary observing network in data-sparse Dronning Maud Land. A critical part of the network is a data management system that will ensure broad, free access to all TONE data to the international research community.

Keywords

Research infrastructure; access to data; international collaboration; atmosphere; solid Earth; marine–cryosphere interaction

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Abbreviations

ACO: Atmospheric Composition Observatory (TONE)
 ATCM: Antarctic Treaty Consultative Meeting
 DML: Dronning Maud Land, Antarctica
 FIO: Fimbulisen Ice Shelf Observatory (TONE)
 IA: Infrasound Array (TONE)
 ICO: Integrated Cloud Observatory (TONE)
 IO: Ionosphere Observatory (TONE)
 MOMO: Multidisciplinary Ocean Moored Observatory (TONE)

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Ekstra lysark

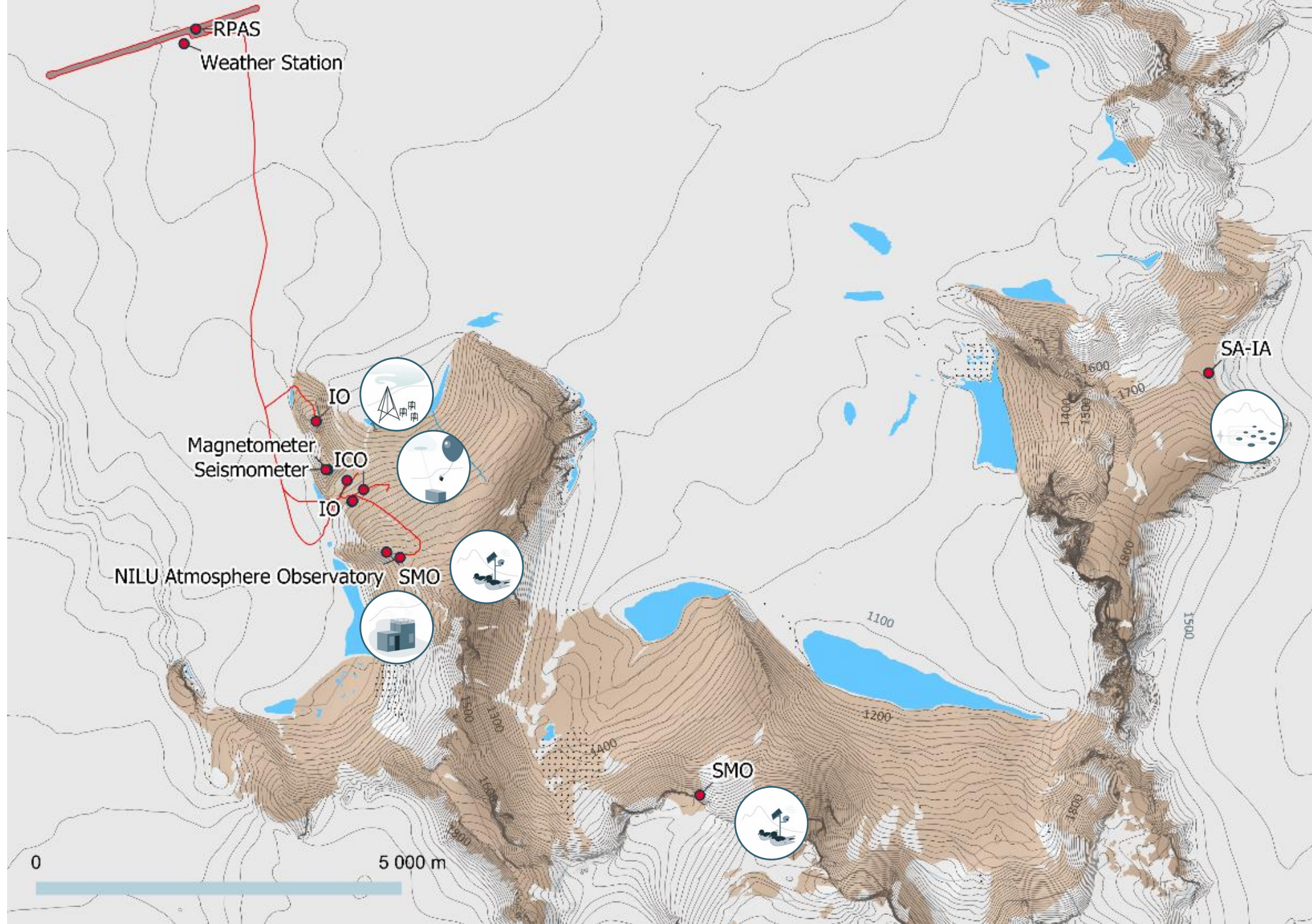


Table 1 Overview of the TONe observatories and services, their instruments, observations, owners and responsible researchers.

Observatory or service ^a	Infrastructure owner (responsible researcher)	Instruments and observed variables
ICO	NPI (Stephen Hudson)	Year-round measurement programme; microwave radiometer, two lidar systems, cloud radar and weather balloons/radiosondes; measures cloud properties (temperature, height, thickness, density and particle size, shape and phase) and their impact on the surface energy balance.
ACO	NILU (Wenche Aas)	Three new instruments: a Piccaro cavity ring-down spectrometer measuring CO ₂ , CH ₄ and CO; a TSI aerosol particle sizer for larger particles (0.6 – 25 µm), a Pandora remote sensing spectrometer for vertical column of trace gases (O ₃ , NO ₂ , SO ₂ and formaldehyde).
IO	Univ. of Oslo (Wojciech Miloch)	Digisonde-Portable-Sounder-4D (a digital ionosonde produced by Lowell Digisonde International), including multiple antennas (transmitter and receiver). The system measures electron density profiles, turbulent structures and their movement in the ionosphere.
IA	NORSAR (Johannes Schweitzer)	An infrasound array consisting of nine sensors (co-located with the nine SA sites) measuring low-frequency sound signals from events in the atmosphere and the ice.
SA	NORSAR (Johannes Schweitzer)	A seismic array consisting of 10 sensors at nine locations will provide information on seismic activity in DML, throughout Antarctica and the whole globe. It estimates amplitude, frequency, velocity and direction of seismic signals caused by earthquakes, icequakes, explosions, etc.

FIO	NPI (Tore Hattermann)	For time series of ice-shelf mass balance and warm-water inflow, instrumentation at two locations will measure currents, temperature and salinity in the water column beneath the ice shelf, turbulence in the ice-shelf–ocean boundary layer, sound sources for future glider campaigns under the ice and melt rate.
MOMO	NPI and Univ. of Bergen (Tore Hattermann and Elin Darelius)	Instrumented ocean moorings over the continental shelf at 6°E for measuring temperature, salinity, currents, ice thickness, oxygen, carbon dioxide, chlorophyll-a, echo soundings and passive acoustics. Navigational instruments for under-ice gliders.
SMO	NPI (Sébastien Descamps)	Automated monitoring using time-lapse camera to provide information about colony size, breeding phenology and breeding success. These observations will be complemented with regional studies from RPAS.
RPAS	NORCE and NPI (Rune Storvold and Stig Flått)	Two large fixed-wing aircraft, with VHF radar system, GHz UWB radar, aerial camera, meteorological sensors and a hyperspectral imager. Encrypted communication system with high bandwidth for line-of-sight transmissions up to 200 km, in addition to satellite communication beyond this. Flight endurance of 10 hours, providing a range of 1000 to 1500 km.
DATA	NPI (Stein Tronstad)	At Troll RS, data are stored on two servers in a cluster, to ensure maximum uptime and secure storage. Via the local station network, they will communicate with the observatories to collect data. Data from observatories that are not connected to the local network will be manually transferred to the server when researchers return from the field.
