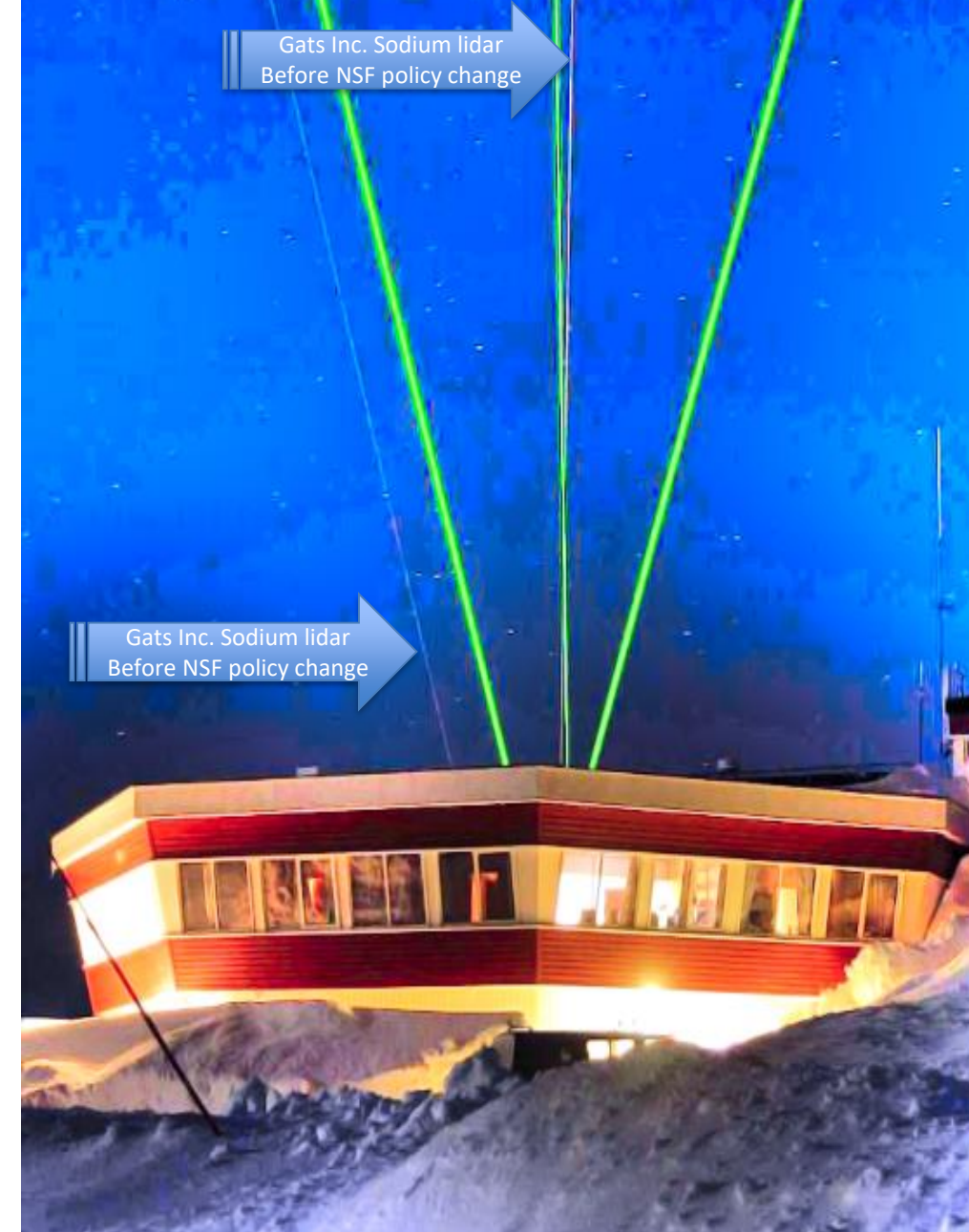




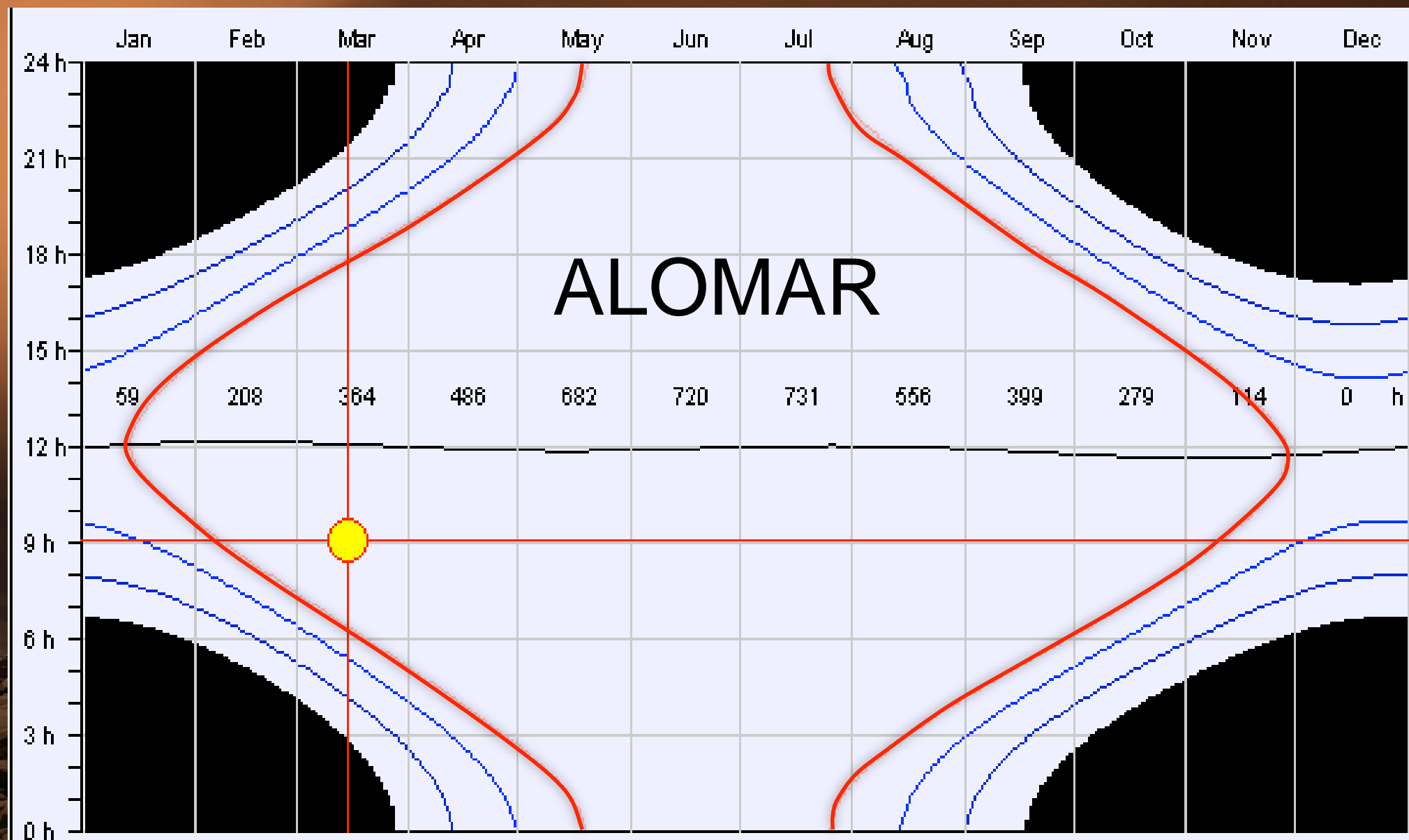
ANDØYA SPACE CENTER

“The ALOMAR Observatory @ Andøya Space Center, how and why?”

Kolbjørn Blix
Dir. of Space Systems dept.



Kolbjørn Blix, CEDAR 2018
June 25th , 2018 - Santa Fe, New Mexico





ANDØYA SPACE CENTER



2007, Kletzing TRICE mission



ANDØYA

THE EUROPEAN AEROSPACE ISLAND

Kolbjørn Blix, CEDAR 2018
June 25th , 2018 - Santa Fe, New Mexico



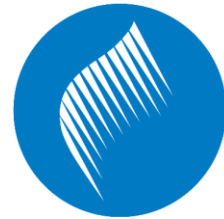
90%

Norwegian Ministry of Trade,
Industry and Fisheries



10%

KONGSBERG



ANDØYA SPACE CENTER



NAROM

Space education



ANDØYA TEST CENTER

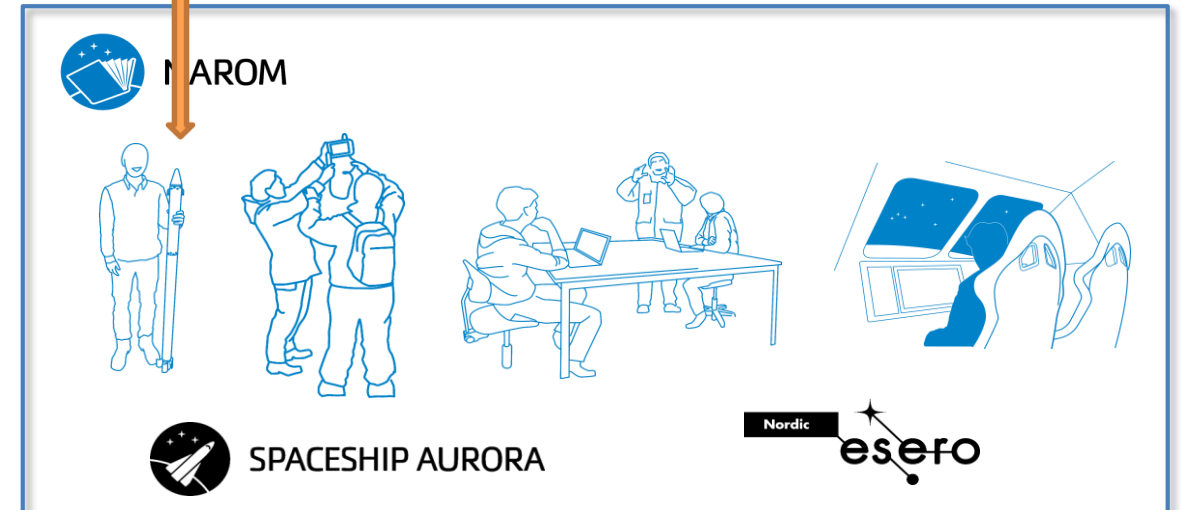
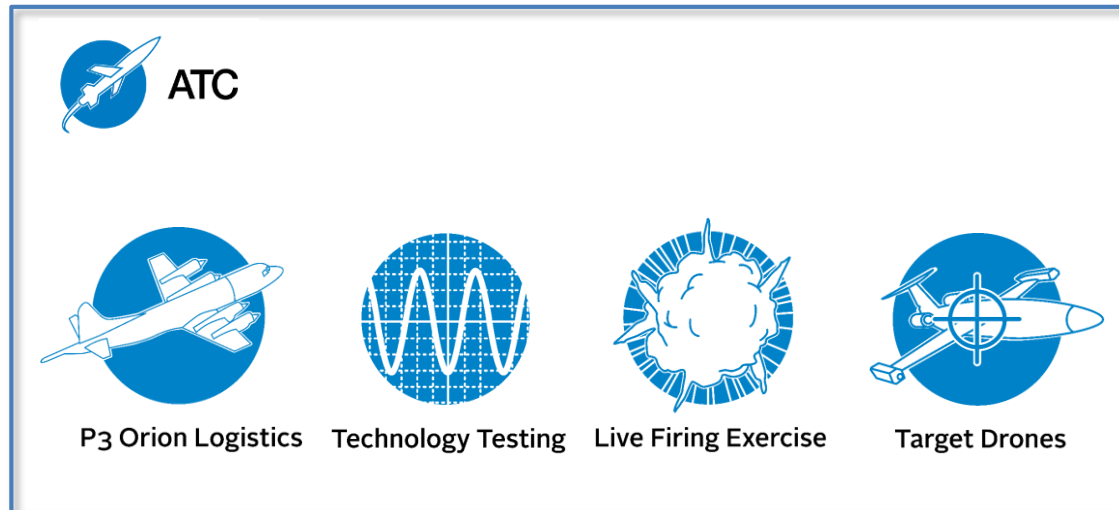
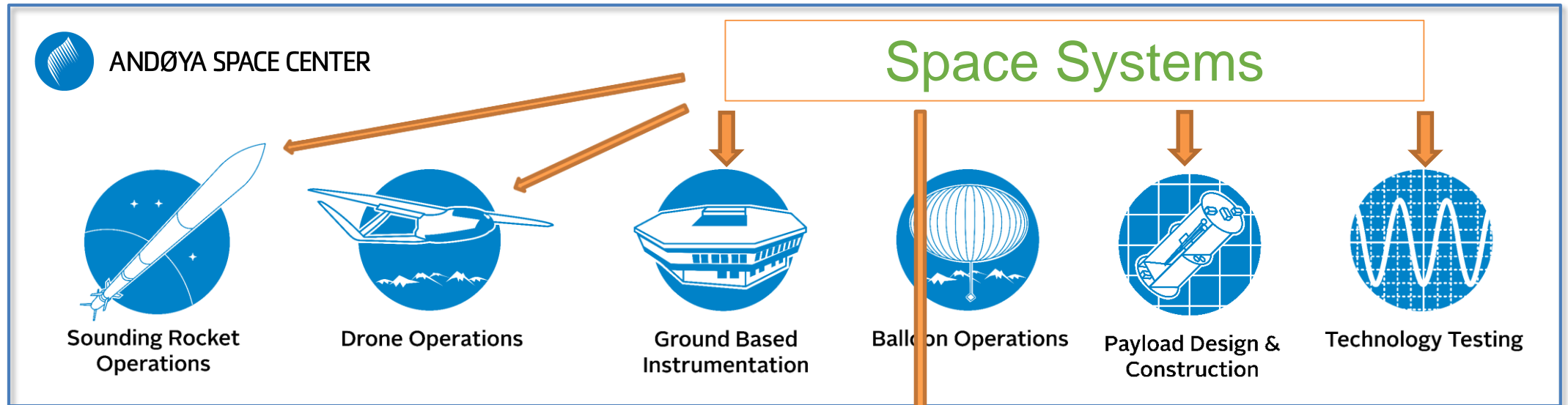
Test range for test and
validation of aerospace- and
ship-based applications



ANDØYA SPACEPORT

Subsidiary established 2018:
Looking into future launch site – polar and SSO
orbiting satellites (450 kg). Decision 2019

ASC activities



ALOMAR Observatory

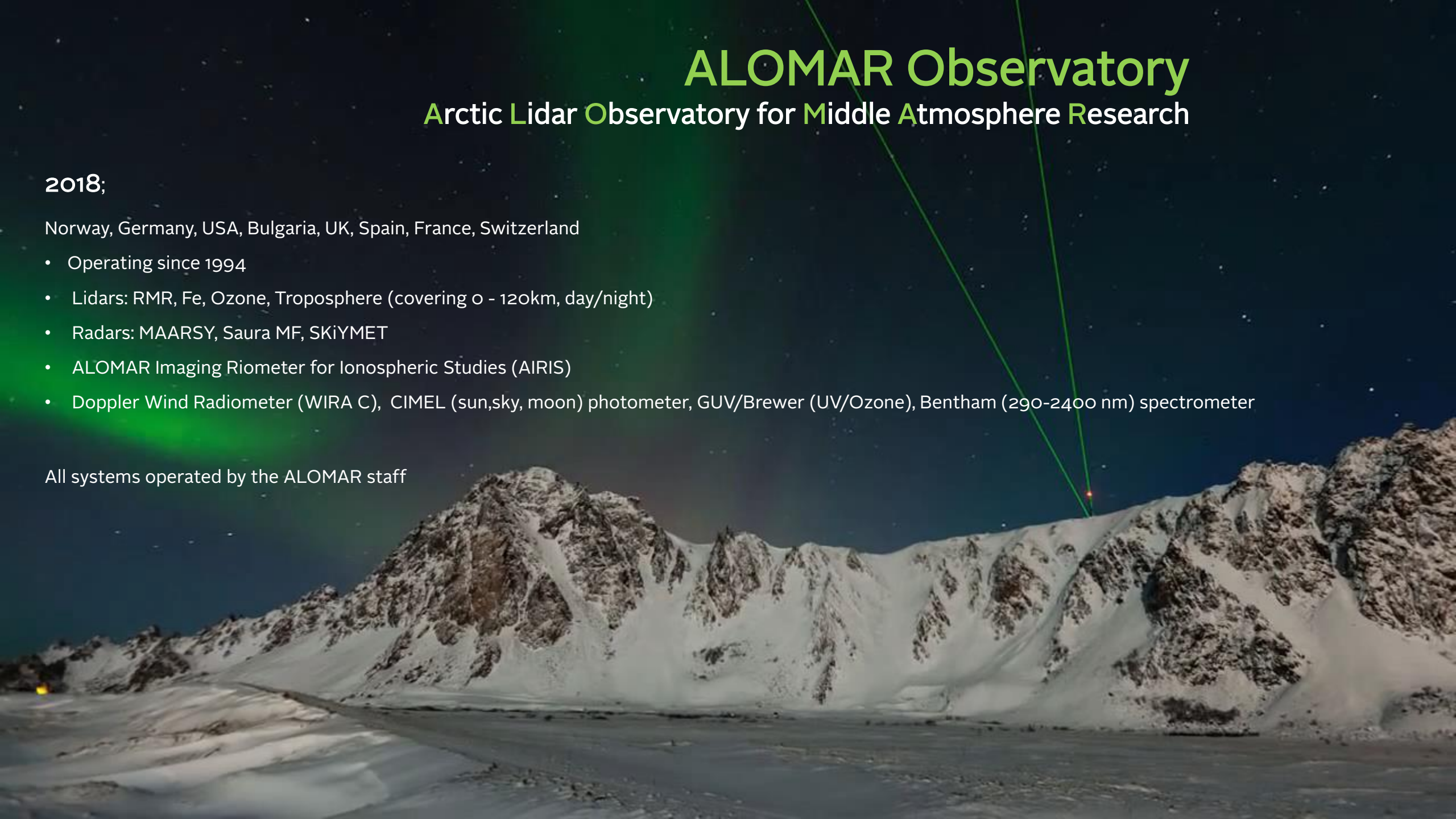
Arctic Lidar Observatory for Middle Atmosphere Research

2018;

Norway, Germany, USA, Bulgaria, UK, Spain, France, Switzerland

- Operating since 1994
- Lidars: RMR, Fe, Ozone, Troposphere (covering 0 - 120km, day/night)
- Radars: MAARSY, Saura MF, SKiYMET
- ALOMAR Imaging Riometer for Ionospheric Studies (AIRIS)
- Doppler Wind Radiometer (WIRA C), CIMEL (sun,sky, moon) photometer, GUV/Brewer (UV/Ozone), Bentham (290-2400 nm) spectrometer

All systems operated by the ALOMAR staff



ALOMAR science topics

Planetary Boundary Layer

Aerosols

Cirrus Clouds

Greenhouse Gases

Ozone Layer

Polar Stratospheric Clouds

Noctilucent Clouds

Gravity Waves

Planetary Waves

Atmospheric Tides

Airglow

Metal Layers (Fe, K)

Winds / temps

Meteors

Aurora Borealis





ANDØYA SPACE CENTER



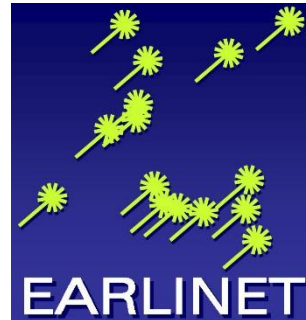
UtahState
University



UiO : University of Oslo

u^b

^b
UNIVERSITÄT
BERN



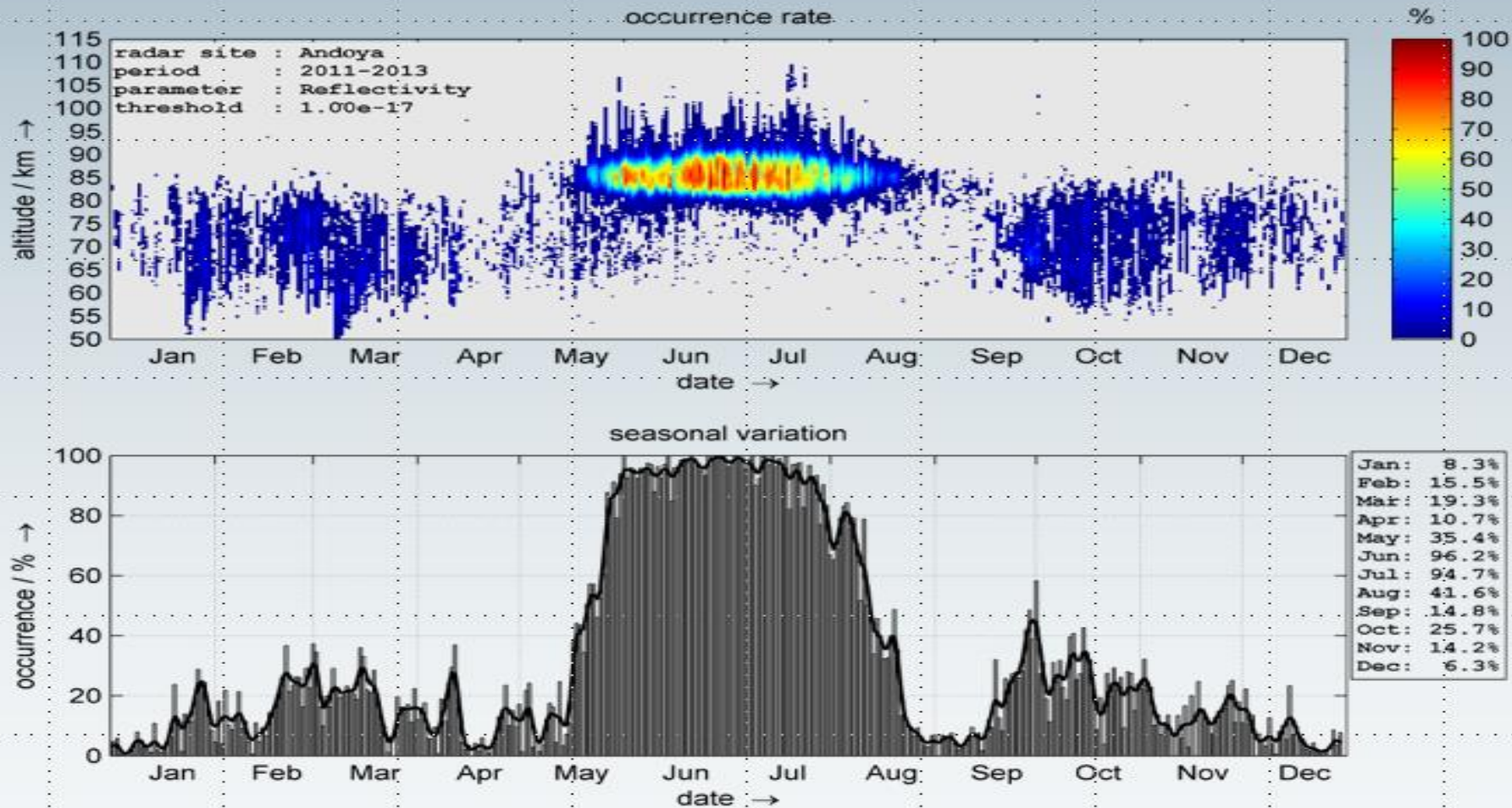
Current partners

ALOMAR RMR Lidar status

G. Baumgarten, J. Fiedler,
A. Brand, G. von Cossart

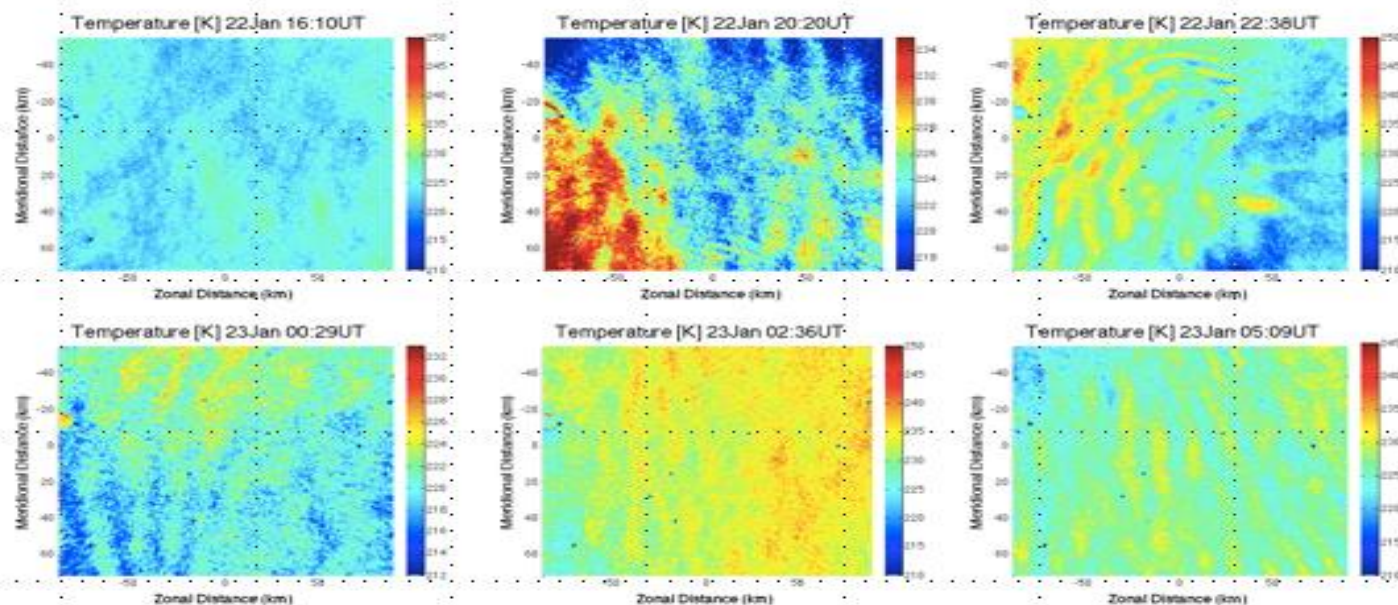


Status of IAP radars on Andøya: MAARSY continuous observations of mesospheric echoes

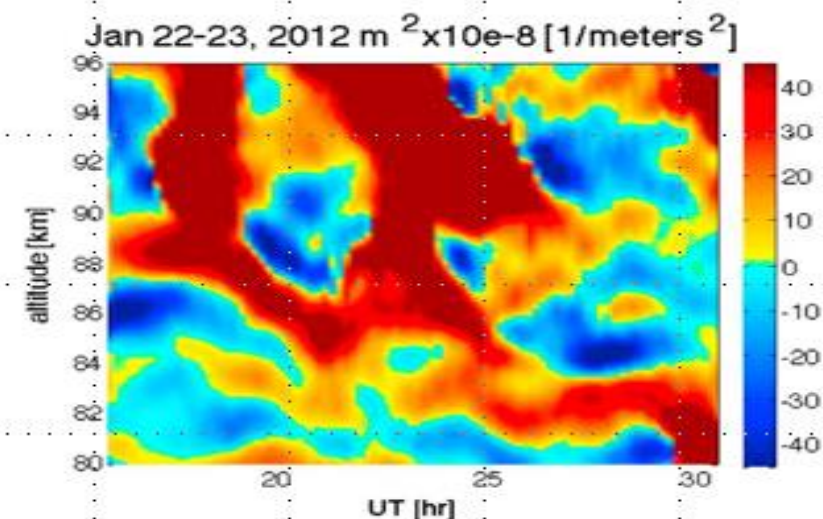
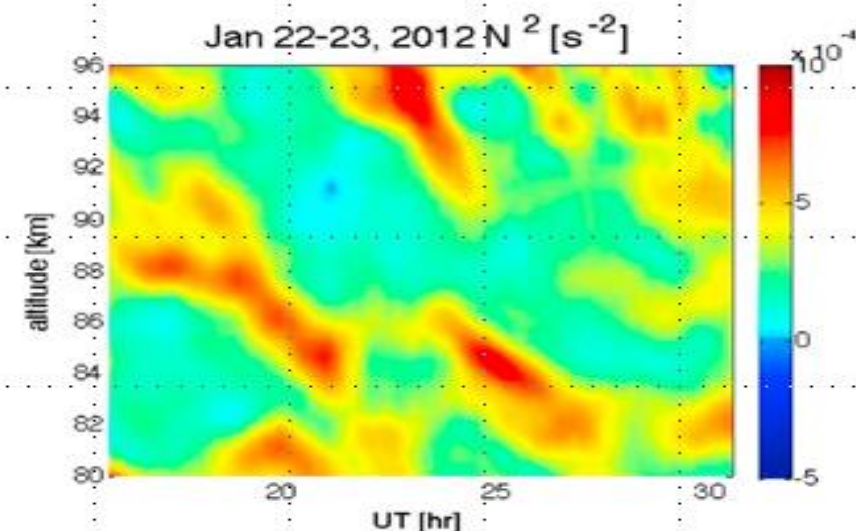


Investigating GW Ducting Conditions over ALOMAR (Bossert et al., JGR, 2014)

GW in AMTM data on Jan22-23, 2013



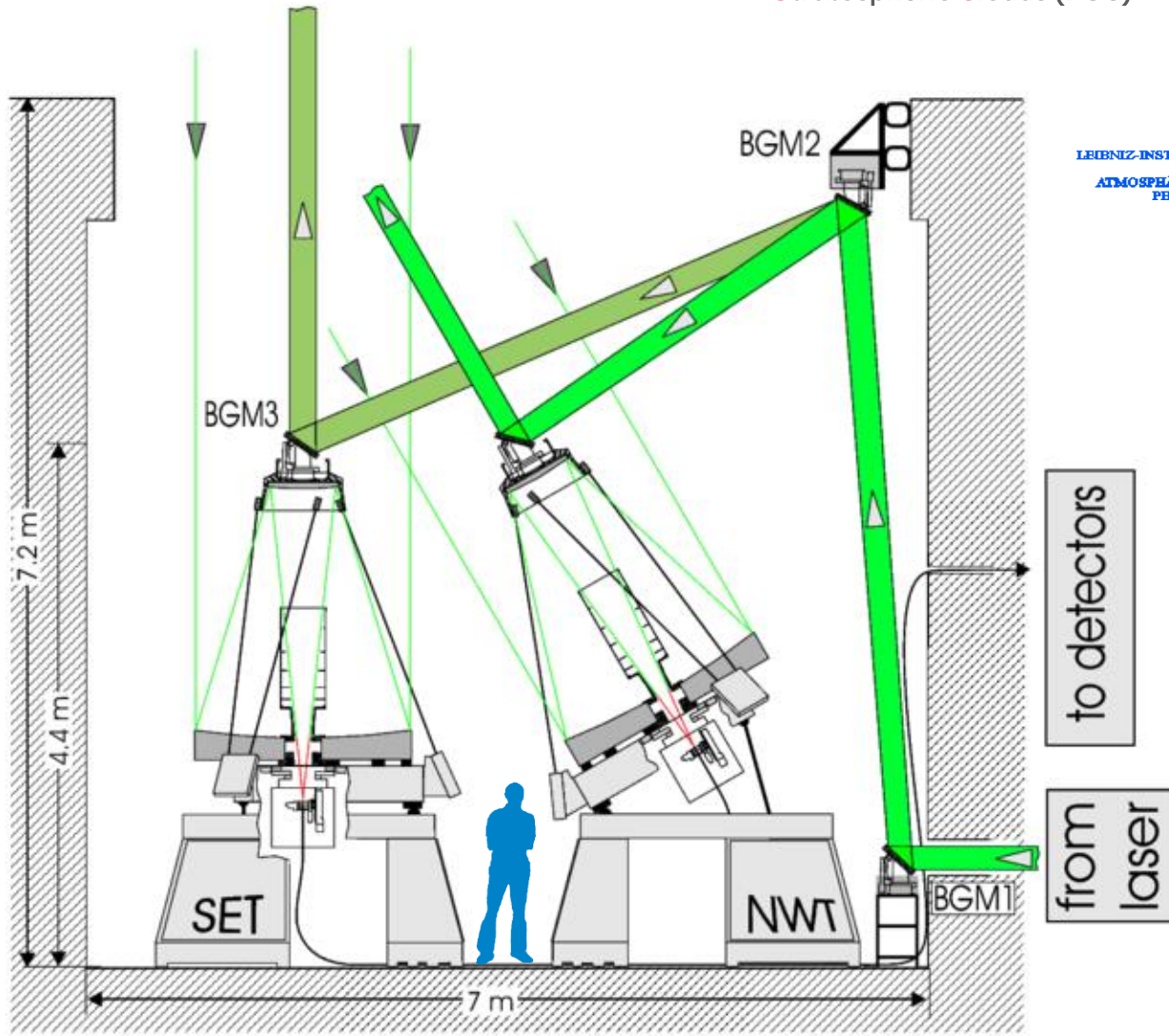
N^2 and m^2 profiles showing the time and height-varying wave ducting environment.





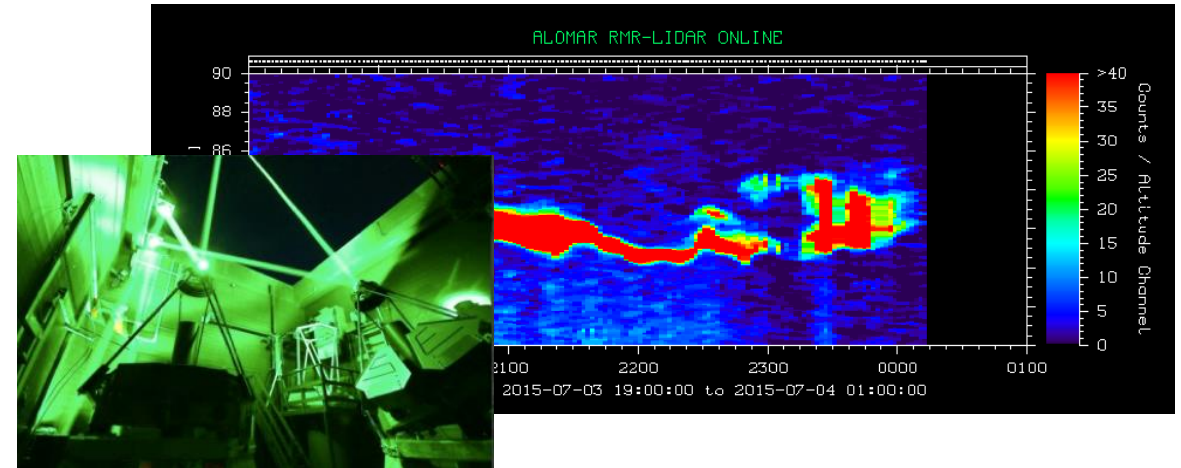
ANDØYA SPACE CENTER

Temp, Winds, Water vapor,
Noctilucent Clouds (NLC), Polar
Stratospheric Clouds (PSC)

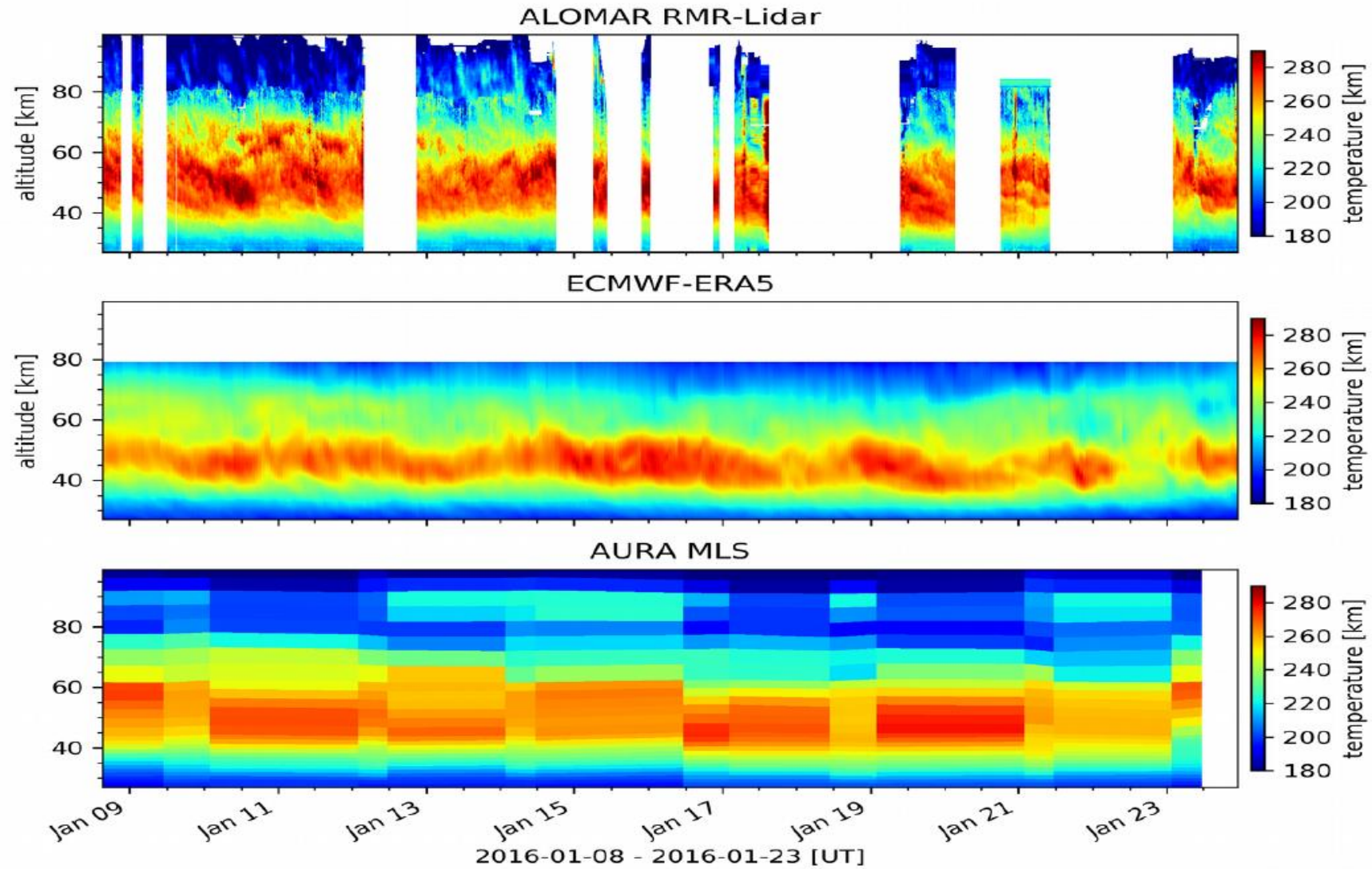


RMR lidar 1994-2018

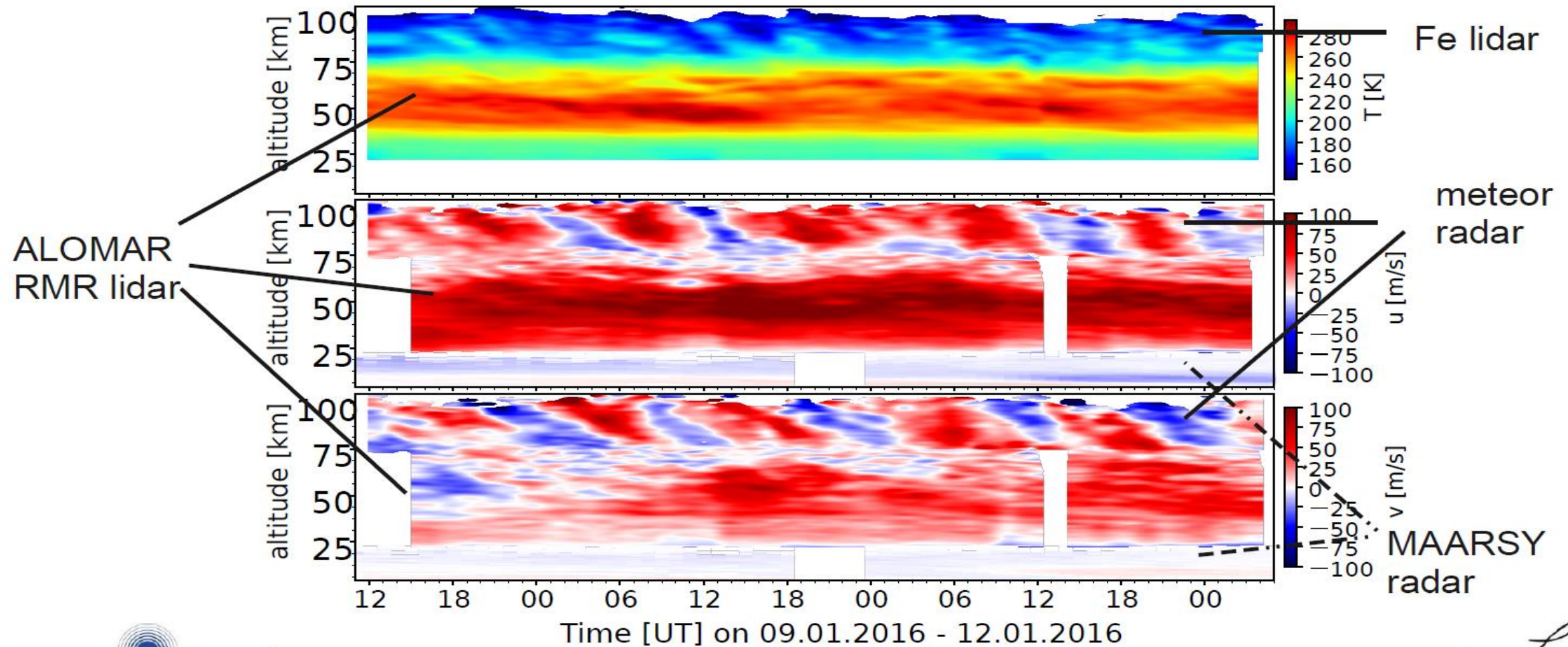
- Tx: 355 nm, 532 nm, 1064 nm from two pulsed Nd:YAG power lasers (peak pulse pwr - 150 MW) (Diode pumped from 2018)
- Scattering mechanisms used for signal detection:
 - **Raman** (inelastic scatter (lower freq by excitation))
 - 532 nm => 608 nm etc..
 - **Mie**
 - **Rayleigh** (elastic scatter (same freq/wavel))
- Rx: 14 channels (355, 387, 529.1, 530.4, 532, 608, 1064)
- Longest measurement: 187 hrs, feb. 2017

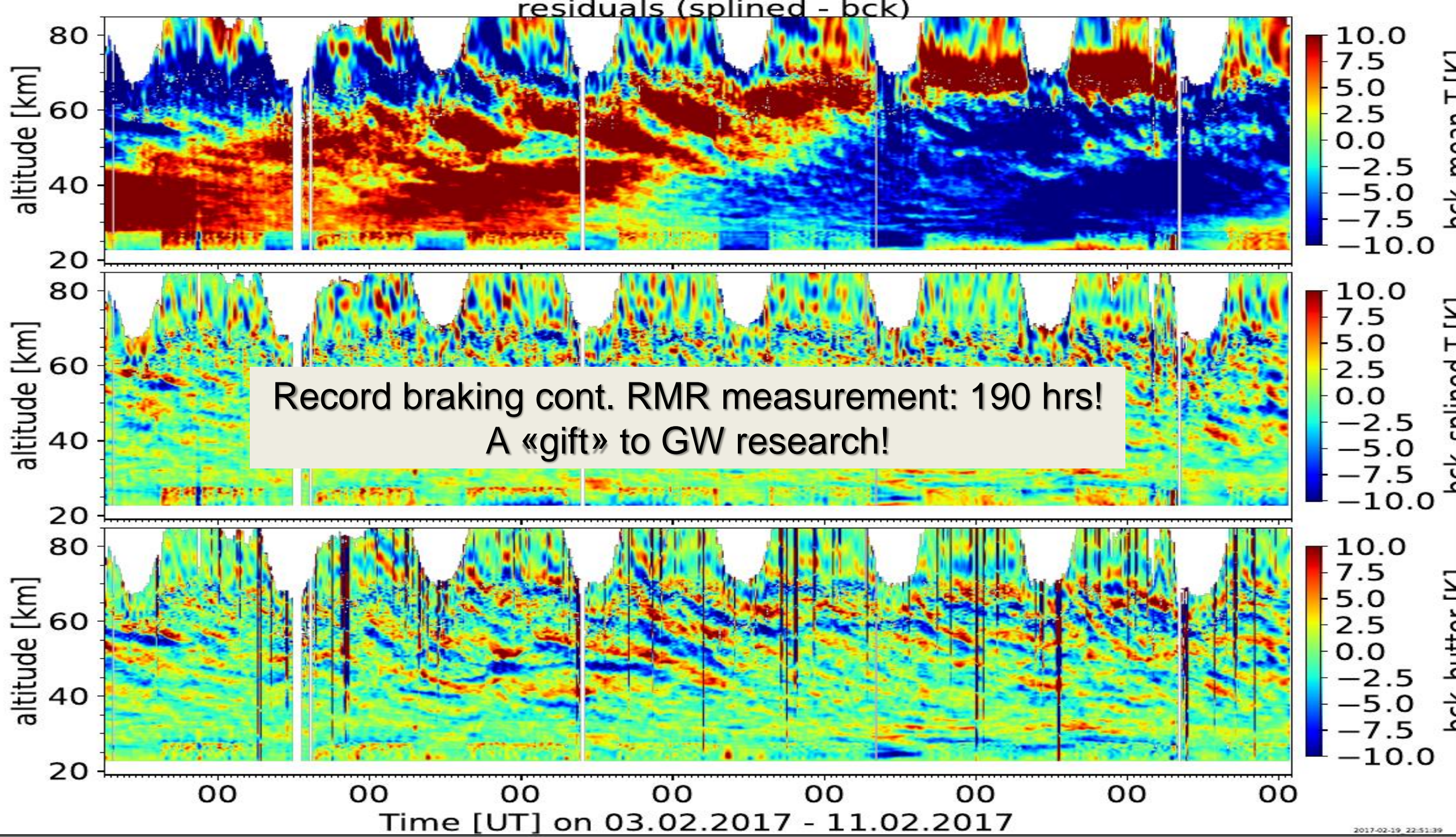


Comparison to newest reanalysis ERA5

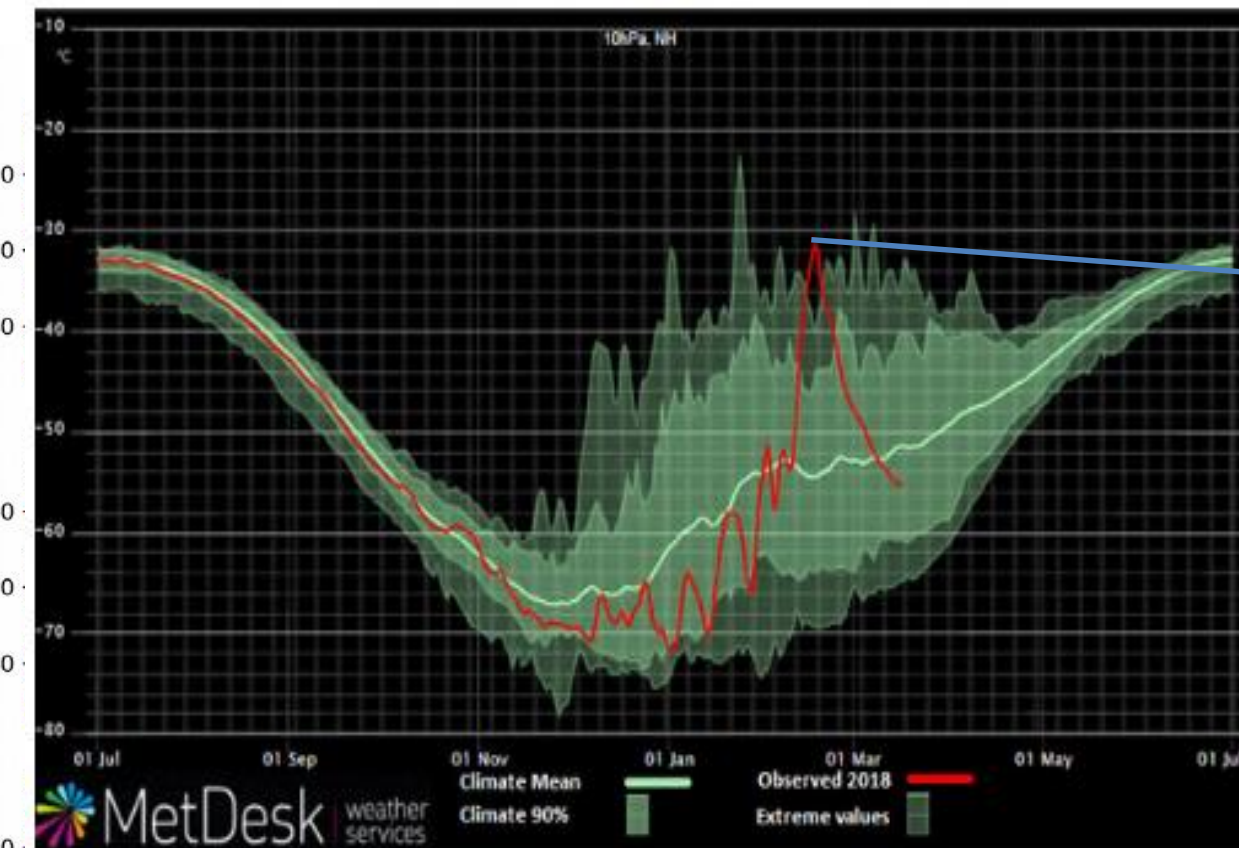


Combined lidar and radar dataset





Exceptional good coverage January – March 2018

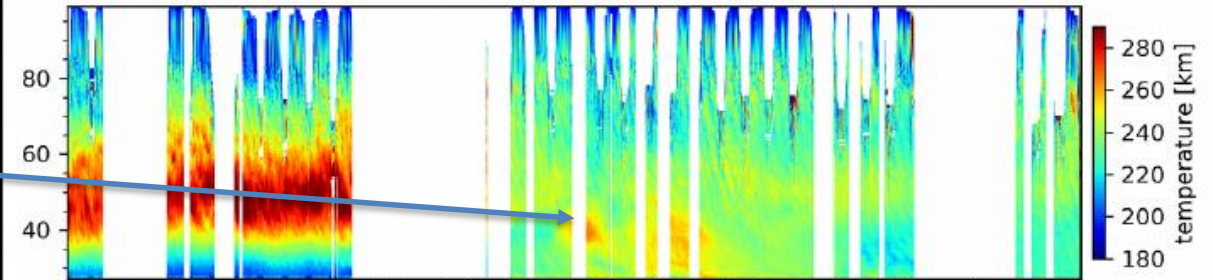


▲ Temperatures in the stratosphere during the northern winter of 2017/18. The red line shows observed temperatures in celcius. Note the sudden temperature increase from the 11 February. Illustration: MetDesk

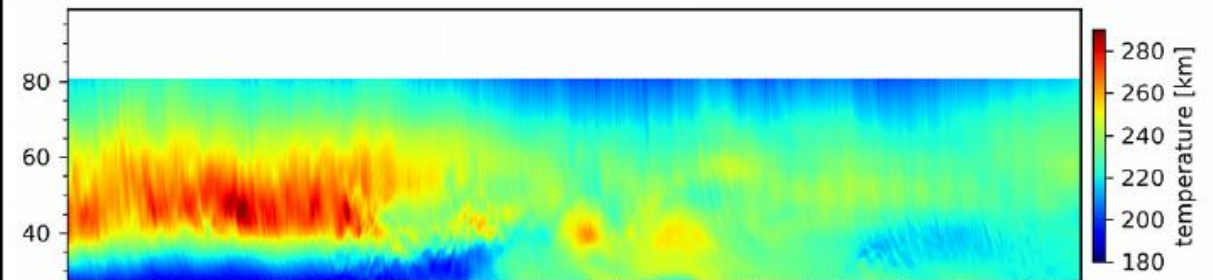
The historic disruptive cold spell at the turn of the month and the brief intense wintry spell last weekend were caused by a record-breaking sudden stratospheric warming (SSW) event that began on 11 February.

2018-04-10 12:00:28

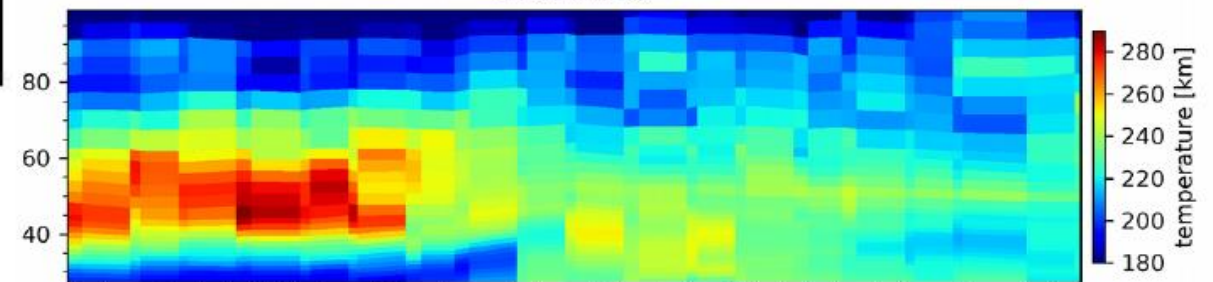
ALOMAR RMR-Lidar



ECMWF-IFS



AURA MLS



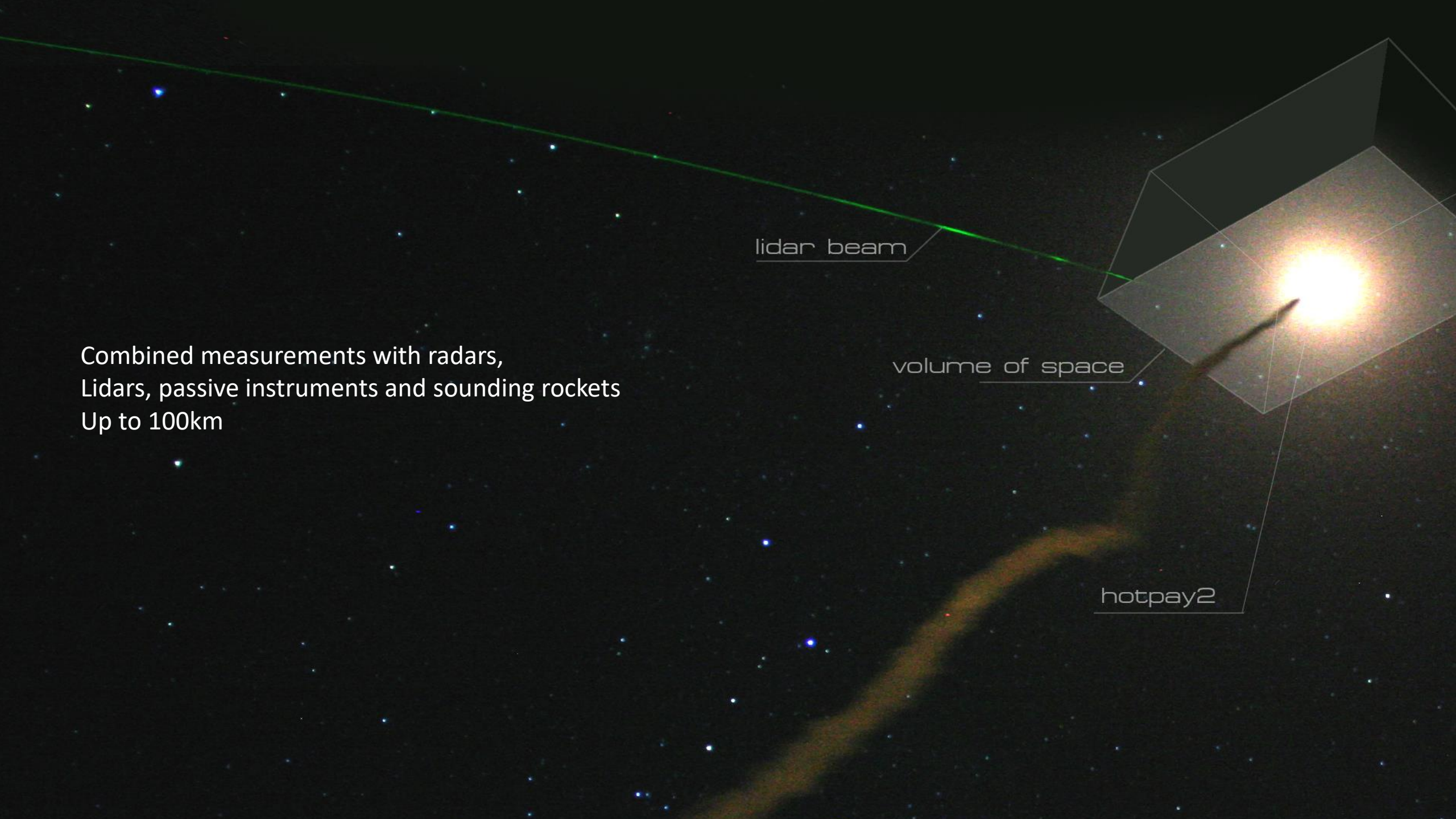
Jan 29 Feb 01 Feb 08 Feb 15 Feb 22 Mar 01
2018-01-23 - 2018-03-06 [UT]

Combined measurements with radars,
Lidars, passive instruments and sounding rockets
Up to 100km

lidar beam

volume of space

hotpay2



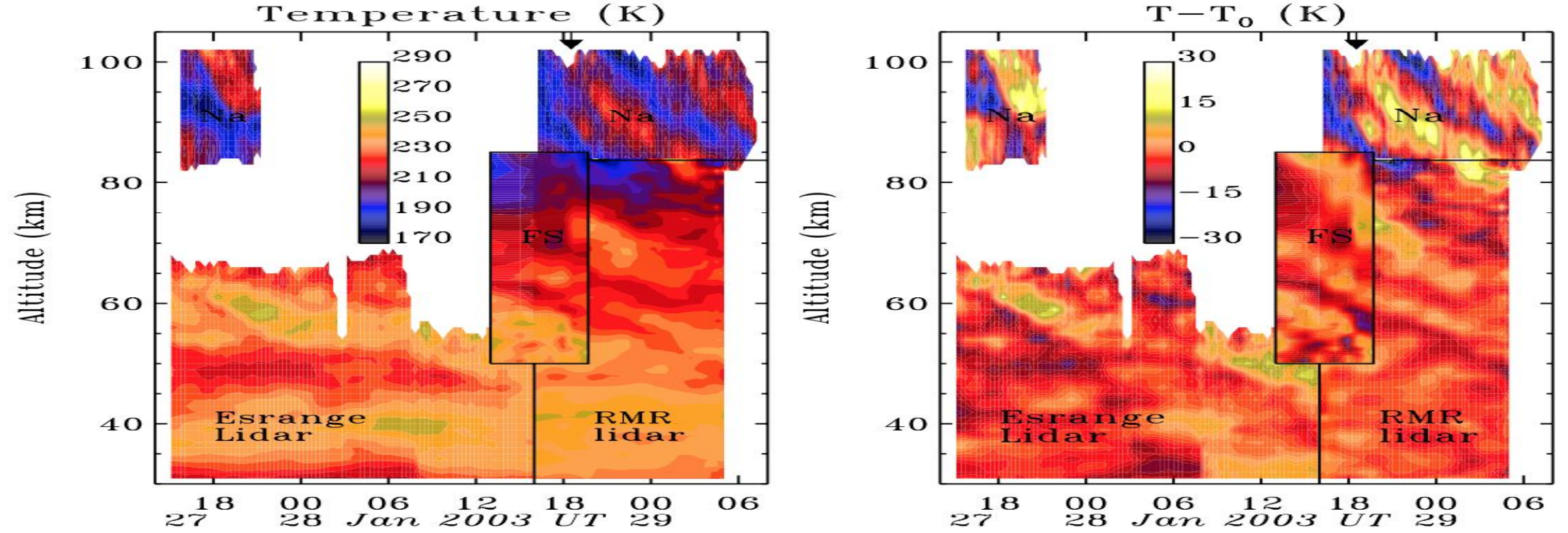
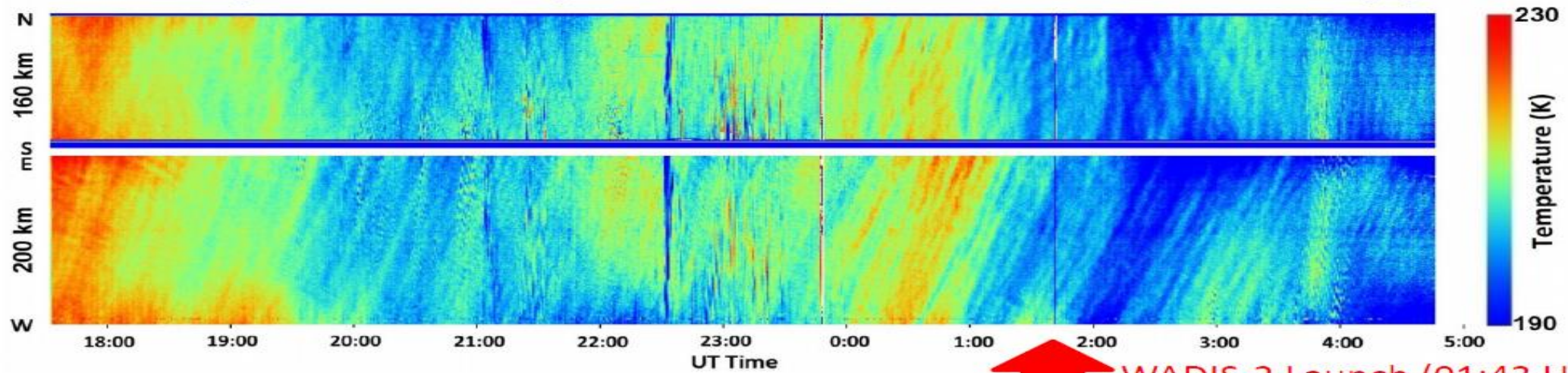


Fig. 15. A temperature (left) and temperature difference (right) map for 27–28 January 2003 as determined by combining RMR and Na lidar data at ARR with RMR lidar and FS data at Esrange. The blocks distinguish the regions where temperature is measured by each specified technique. In the right panel, T_0 indicates the mean temperature profile within the specified block. The small arrow at the top of each panel represents the launch of NASA 41.031 on 28 January 2003. The figure emphasizes the consistency between sites and large-scale of the planetary wave observed above 80 km. The difference map also shows small-scale structure superimposed on the large wave.

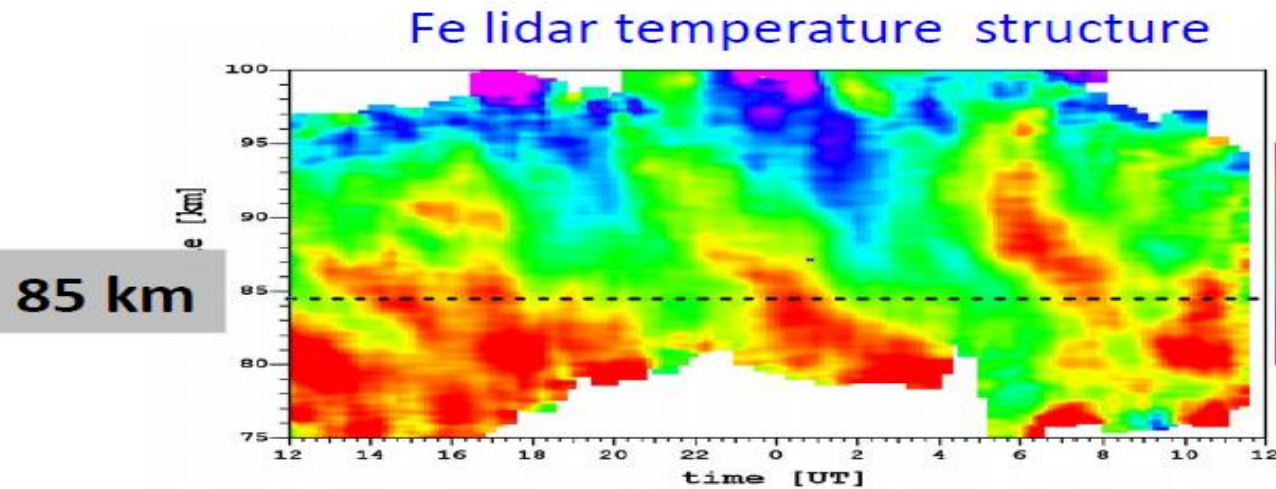
AMTM Comparative Measurements

WADIS-2 (March 4/5, 2015)

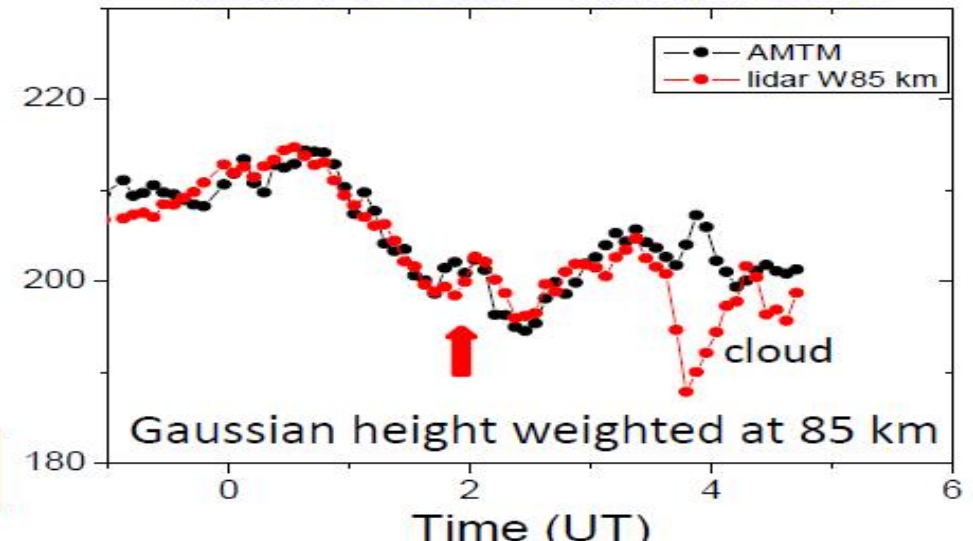
Clear sky dominated by continuous small-scale wave activity (00-03 UT)



WADIS-2 Launch (01:43 UT)



RMR-Fe Lidar - AMTM data



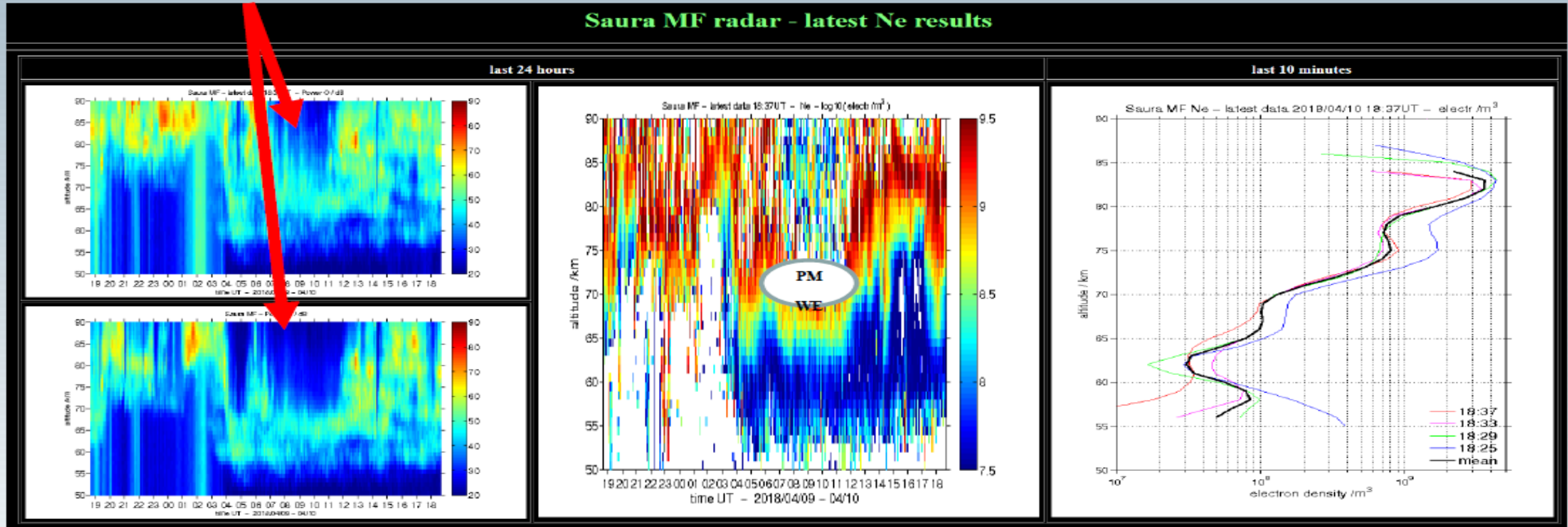
Result: OH (3,1) layer at 85 ± 1 km during mission

Saura MF radar / PMWE1

real time presentation of scanning results at USOC

Enhanced ionisation
> Radio wave absorption

Saura MF radar - latest Ne results



Satellite validation @ ALOMAR

ADM-AEOLUS ~2017...

Collecting important data in relation to the improvement of weather forecasts in the north:

- The Aeolus satellite carries just one large instrument – a laser Doppler wind lidar called Aladin that will probe the lowermost 30 km of the atmosphere to measure the winds sweeping around our planet.
- Important for operational safety in primary industries to Norway in the north; petroleum and fisheries.
- ✓ ALOMAR application for participation approved by ESA
- ✓ ALOMAR funding for ADM-Aeolus cal/val approved by NSC 2017

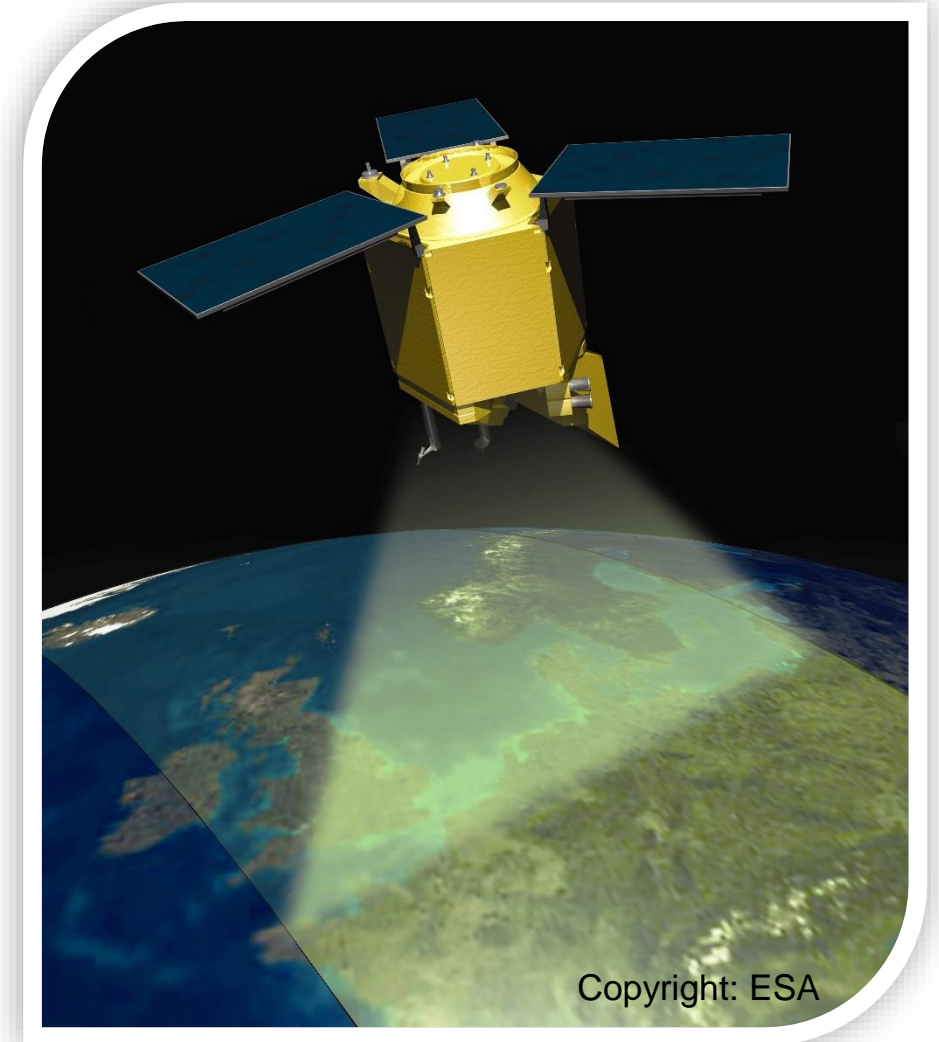


Satellite validation – Sentinel 5P

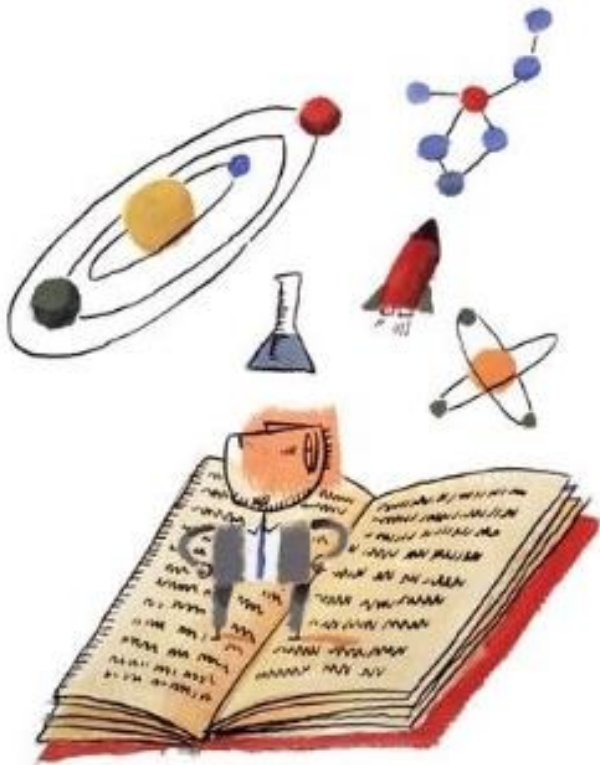
- Carries the Tropospheric Ozone Monitoring Instrument, TROPOMI to provide data on trace gases and aerosols
- Co-operation with NILU, GOA and FMI
- Instruments at ALOMAR used for ground truthing:
 - Ozone lidar
 - GUV/Brewer data
 - Cimel moon/sun photometer
- Expected launch: ~2018
- ✓ ALOMAR application for participation approved by ESA
- ✓ ALOMAR funding for S5P cal/val approved by NSC 2018



FMI



Copyright: ESA



ALOMAR

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[1994](#) , [1993](#) ,

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Found Publication: 525



Birkeland currents:

- Set of currents that flow along geomagnetic field lines connecting the Earth's magnetosphere to the Earth's high latitude ionosphere
- Birkeland currents predicted by Kristian Birkeland (UiO) 1908
- Confirmed by satellite 1967
- Now to be measured by TGO, using lidar at ALOMAR...
- Operational ~2019
- Campaigns (new moon, dark period)
- Modelling work will continue in parallel

UiT
THE ARCTIC
UNIVERSITY
OF NORWAY

The mesospheric sodium layer as a remotely, optically pumped magnetometer for investigation of Birkeland currents (MOM)

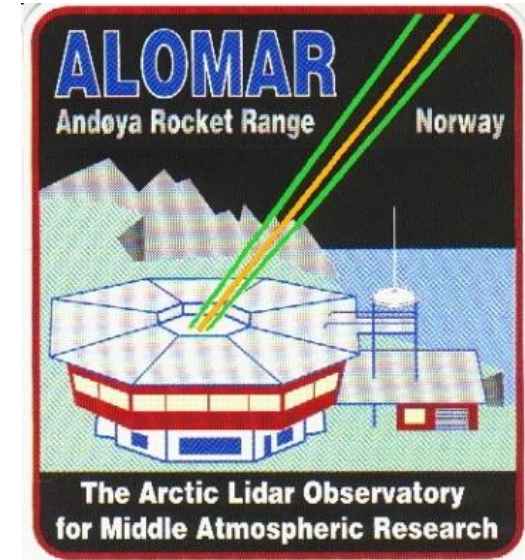
The diagram on the right illustrates the Earth's magnetic field with current regions and types. It shows 'Region 1' and 'Region 2' in the magnetosphere, with 'Field-aligned Currents' flowing along the field lines. Near the ionosphere, 'Pederson Currents' and 'Hall Currents' are shown. The diagram also indicates latitudes of 60°, 70°, and 80°.

Magnar G. Johnsen
ASAC meeting, Vienna 2017



ASC pre-study into (incl. cost):

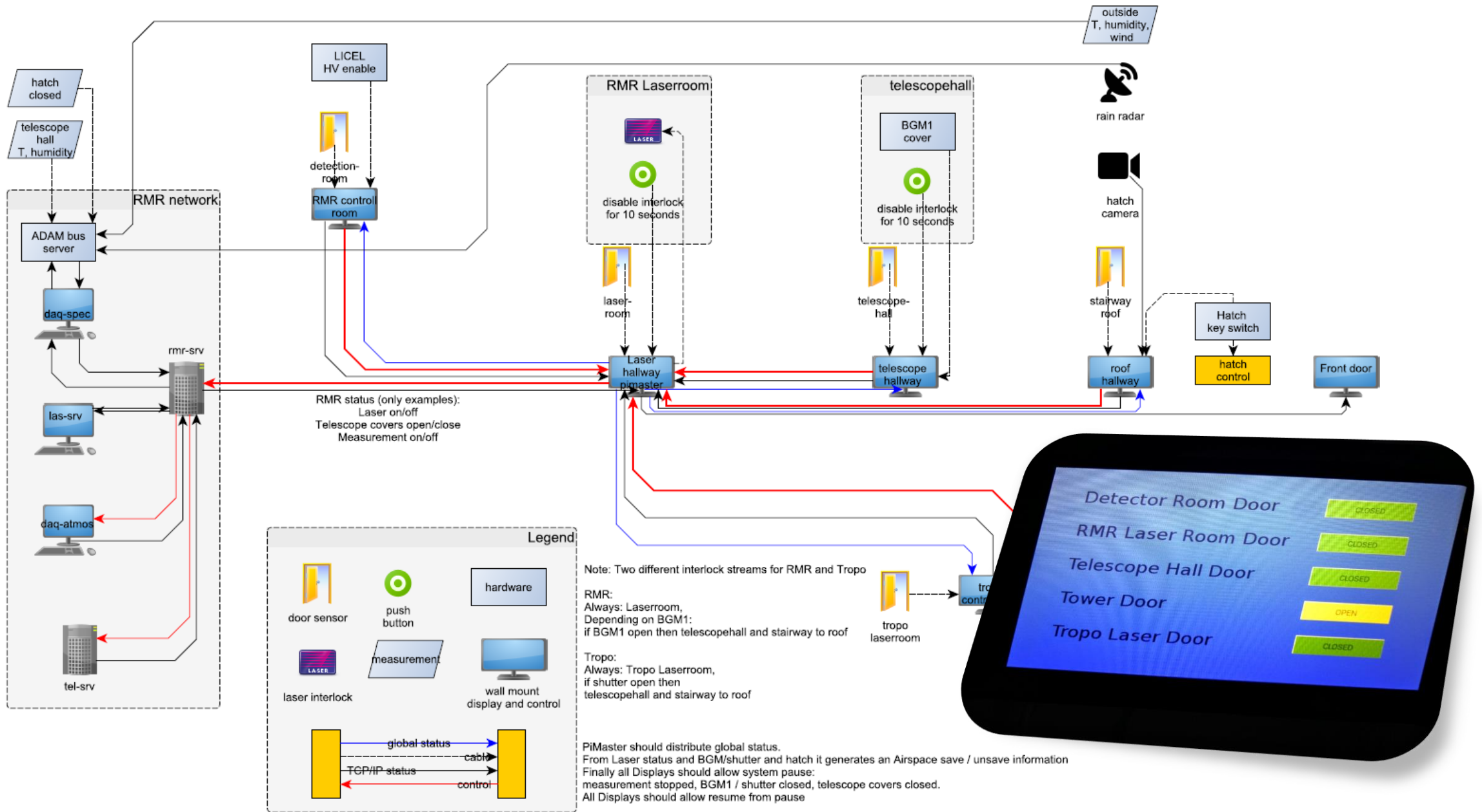
- Automation of multiple functions at the observatory to allow autonomous or "remote" measurements
- Necessary measures like local weather sensors and warning systems to safeguard people, instruments and measurement quality
- Remote control (opening / closing) of roof hatch with automatic safety systems
- Automatic fire and safety systems
- Emergency power system and more
- Staff issues



ALOMAR sticker 1994

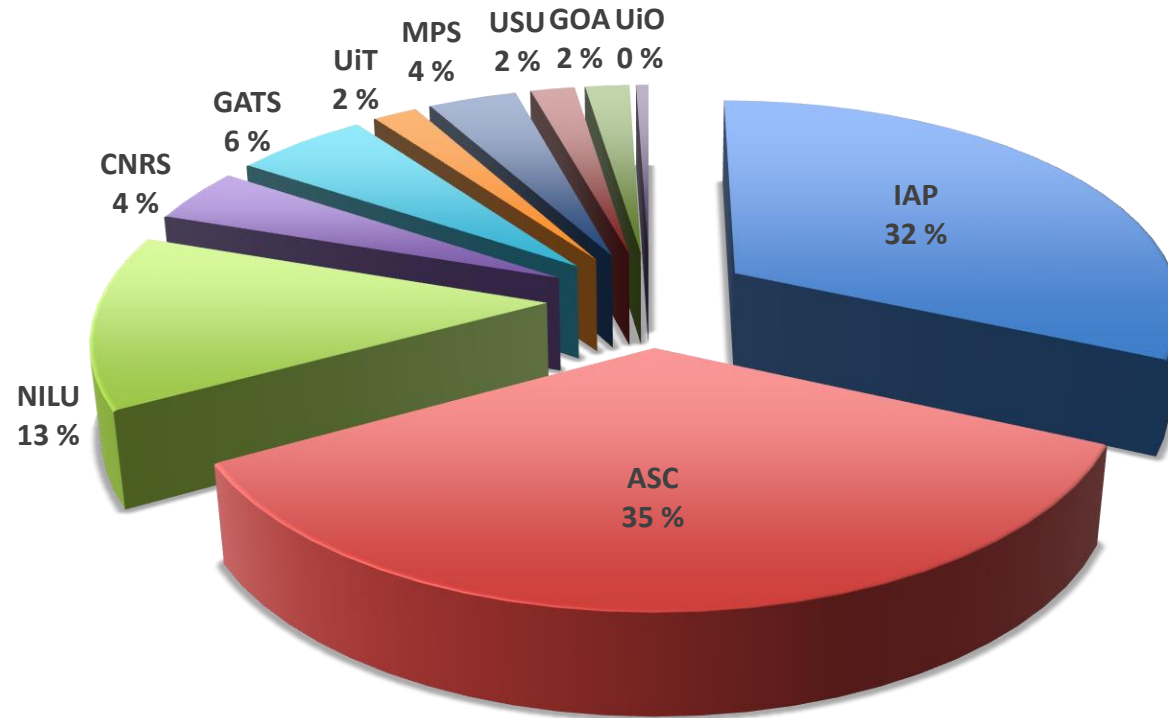
- Partly ASC contribution to EU program ARISE2 WP.4

ALOMAR Lidar Operation Health Administration - ALOHA





ALOMAR Unit distribution 2016



«whole cake» = \$306.000 per year

Includes:

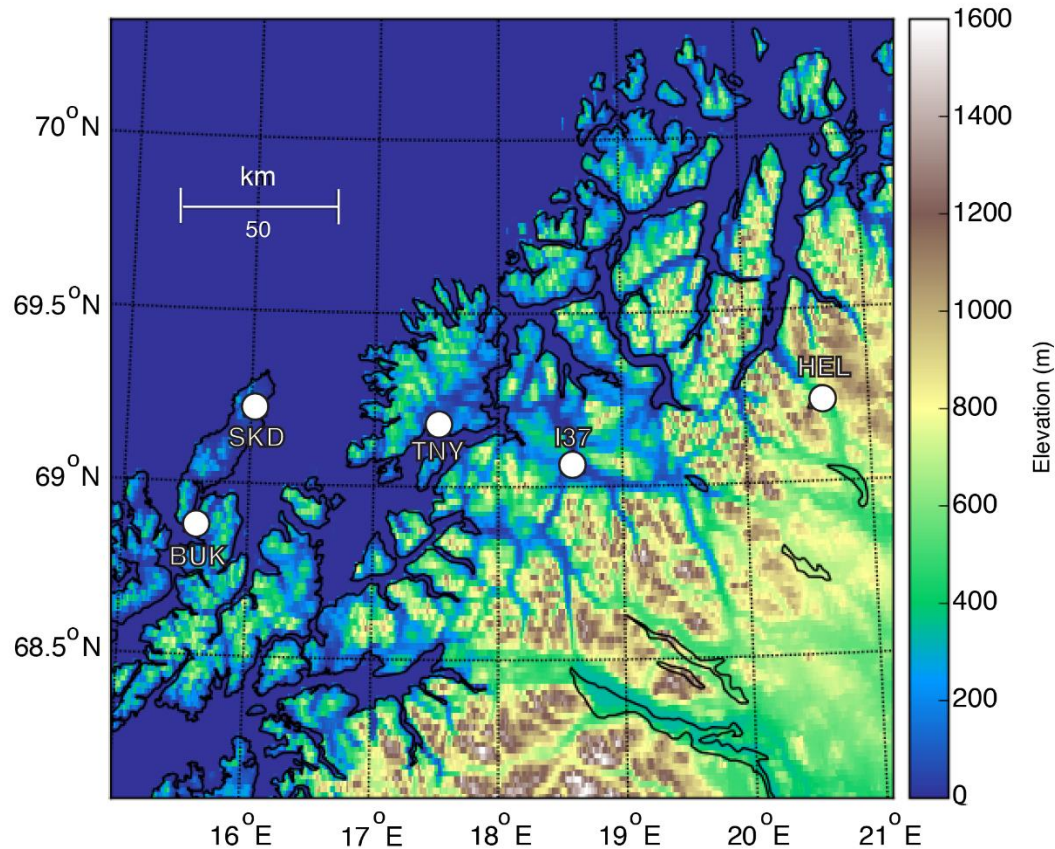
1. Maintenance technical equipment
2. Weekly cleaning ALOMAR building
3. Full time engineer position
4. Road maintenance, snow removal
5. Electricity
6. Gigabit fiber network
7. ALOMAR dedicated 4WD cars

In addition:

- Fixed contracts for appropriate projects
- Periods (years) without AU payments in times of difficulty

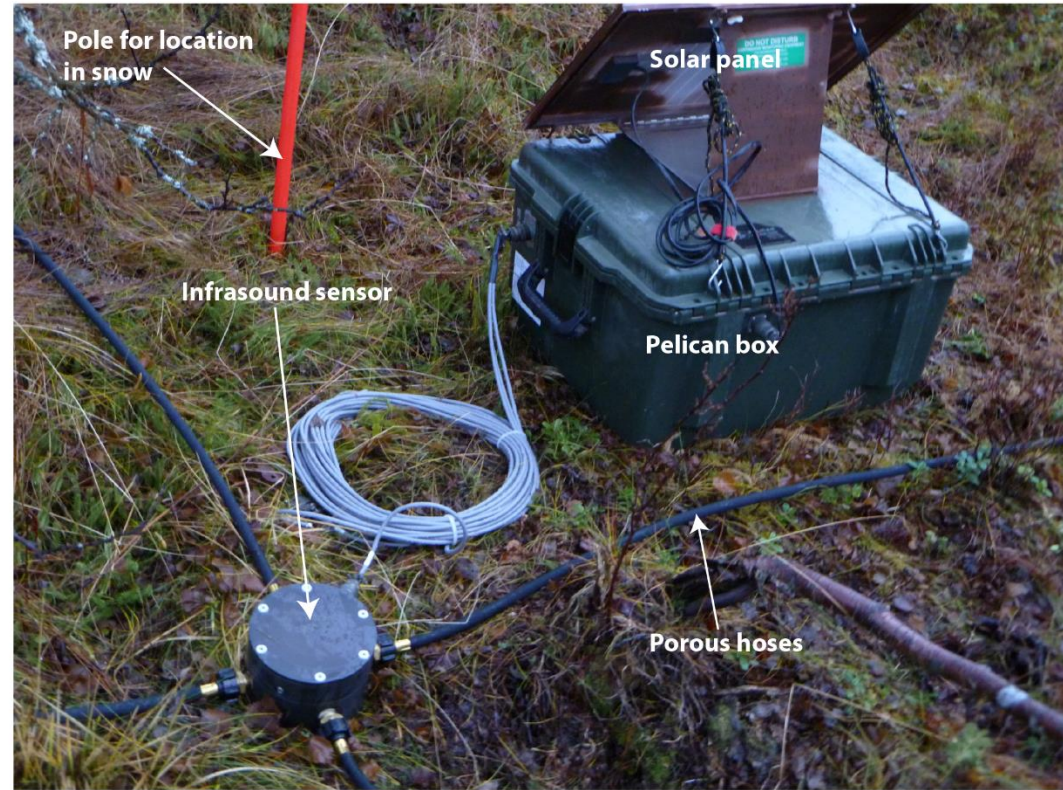
■ IAP ■ ASC ■ NILU ■ CNRS ■ GATS ■ UiT ■ MPS ■ USU ■ GOA ■ UiO

$$2016: 1 \text{ AU} = \$306.000/26 = \$11.769,-$$



The NORSE network comprises five arrays of sensors located along a WSW-ENE trend. Each array comprises multiple microbarometers.

Courtesy of S. Arrowsmith, LANL



Want to derive stratospheric winds from infrasound and compare with wind data from lidar



ALOMAR – an observatory to share....

Thanks to:

- National Science Foundation (NSF)
- Leibniz-Institut für
Atmosphärenphysik, Kühlungsborn,
Germany
- Utah State Univ., USA
- Gats Inc., USA
- Tromsø Geophys. Obs., UiT, Norway
- DLR, Stuttgart, Germany
- ALOMAR Staff



Baked by Malin and Ingrid @ ALOMAR - 2017