Sounding rocket project by

LEIBNIZ-INSTITUT FÜR ATMOSPHÄREN PHYSIK IAP

Supported by:

Federal Ministry for Economic Affairs and Energy

on the basis of a decision by the German Bundestag

PMWE - Polar Mesospheric Winter Echos: role of the dynamics and trace constituents

Project Partners:

LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

IRS Institut für Raumfahrtsysteme

MORABA MOBILE RAKETENBASIS

TU Graz

MISU-IMI

IRF

EISCAT SCIENTIFIC ASSOCIATION

DLR Deutsches Zentrum für Luft- und Raumfahrt

Andøya Space

Authors

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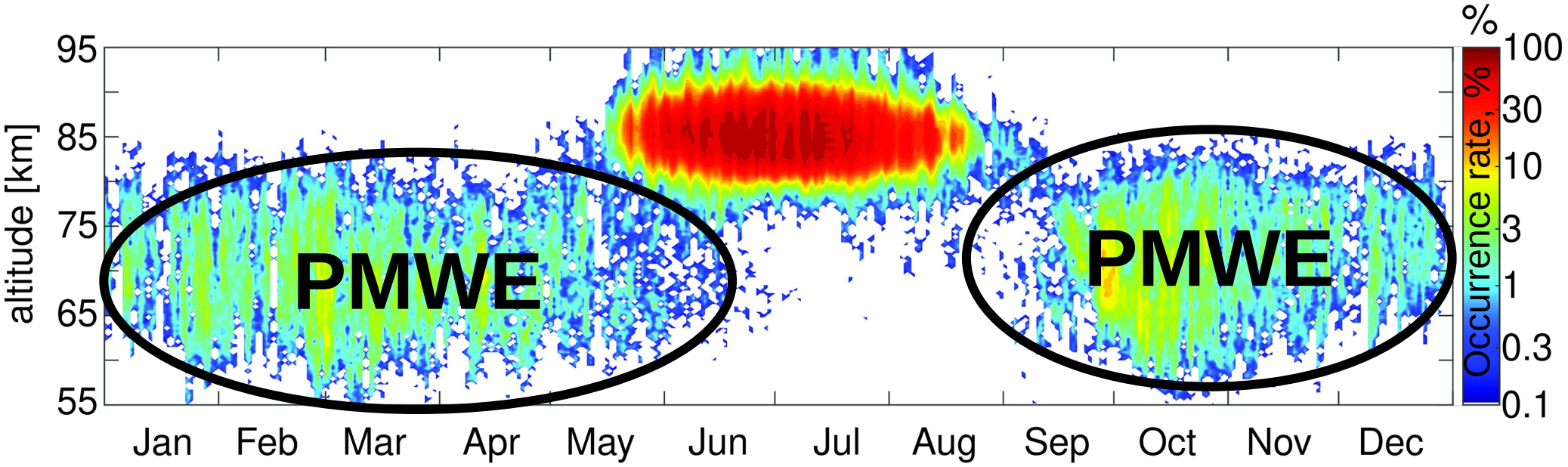
Why study PMWE

As an example, MAARSY (MST radar) observations of echoes over Andøya (69°N)



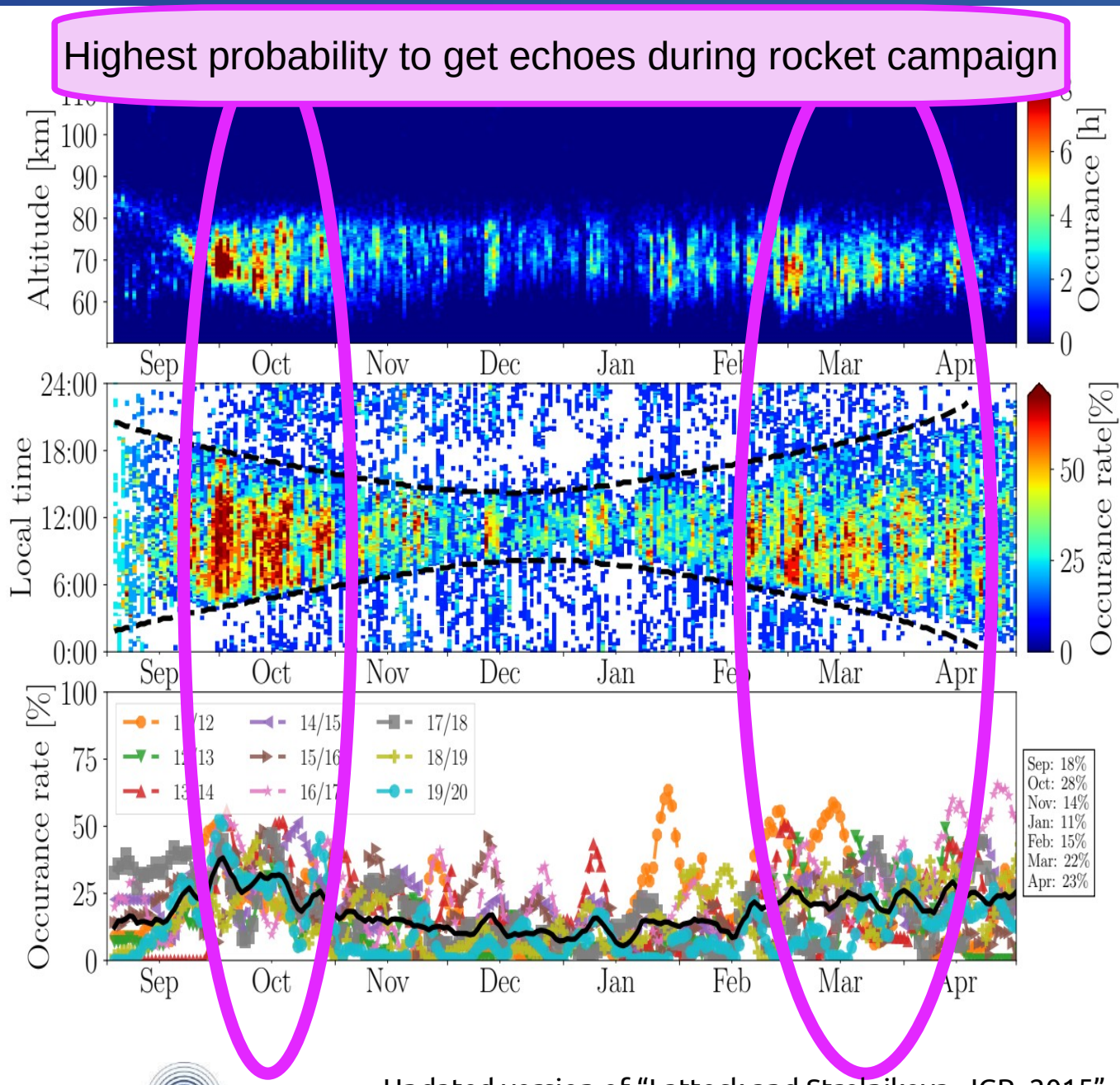
Ralph Latteck, et al., JASTP, 2021

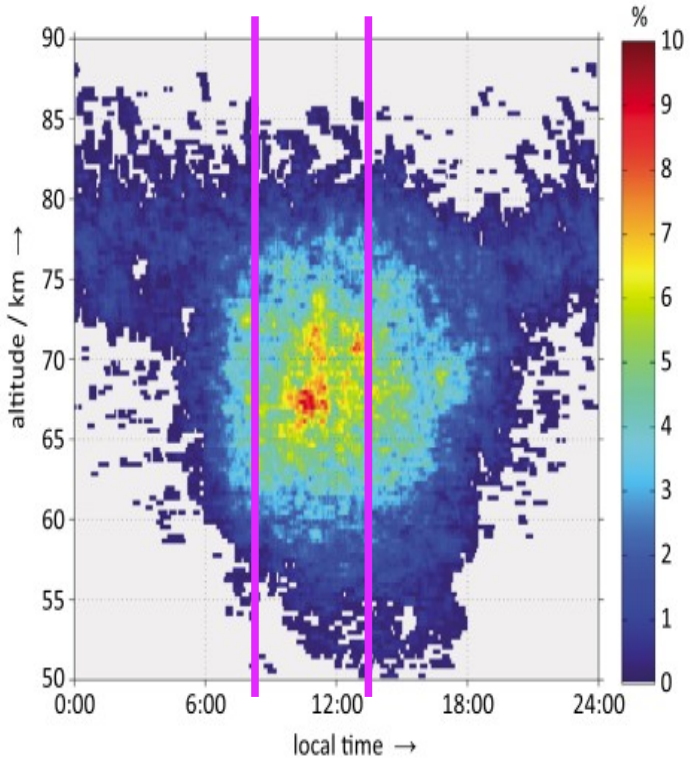
Radar echoes may be used to study MLT dynamics during the whole year.
BUT
we have to know the physics!
PMSE (summer echoes) are well understood,
whereas PMWE (winter echoes) are NOT understood.

Science question: how the structures causing the PMWE are created?

PMWE statistics used to define launch window

Highest probability to get echoes during rocket campaign





Launch window
08:00-15:00 LT

Updated version of “Latteck and Strelnikova, JGR, 2015”, courtesy Ralph Latteck

Rockets, lidars, & radars: Simultaneous and common volume measurements

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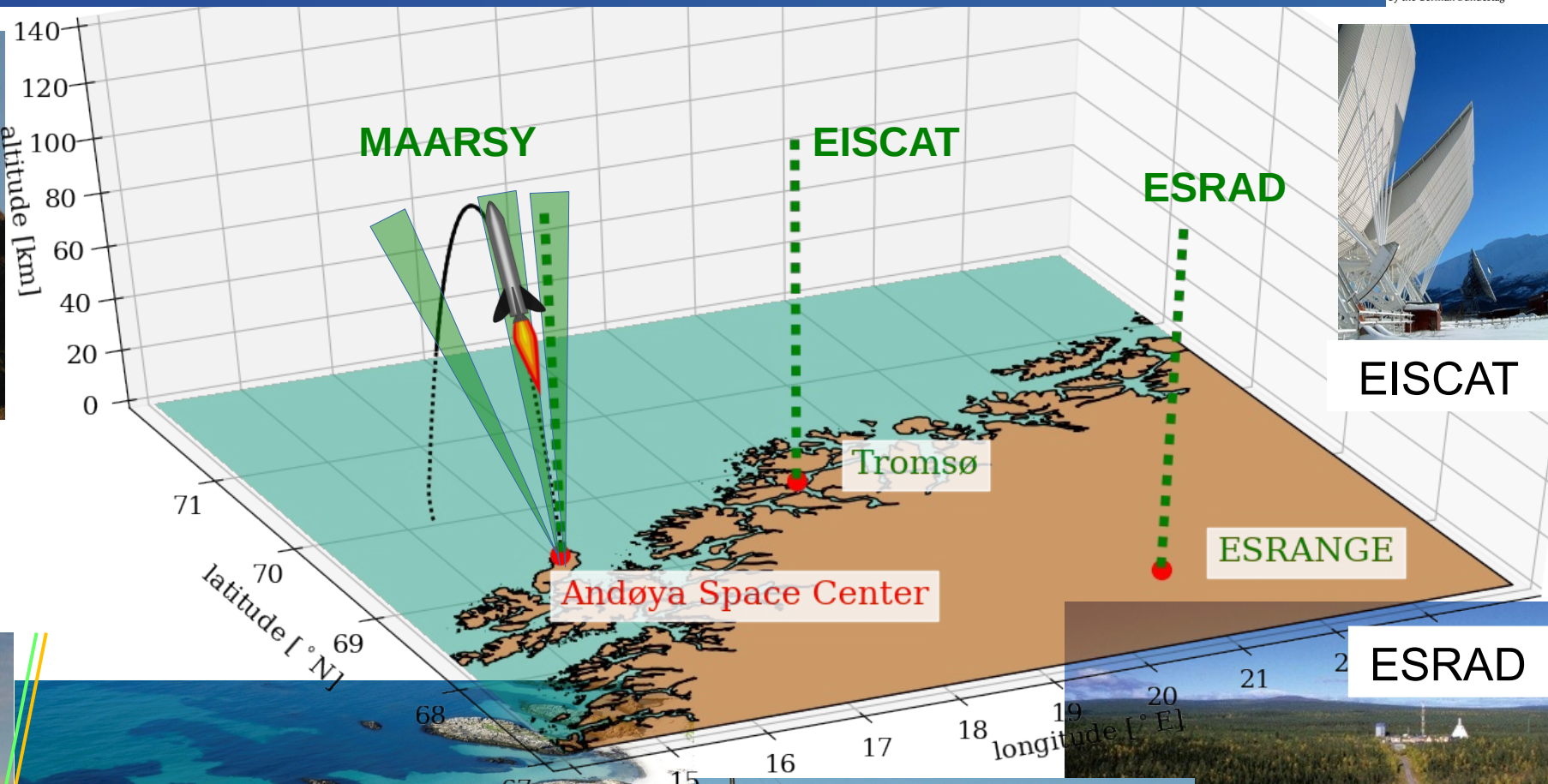
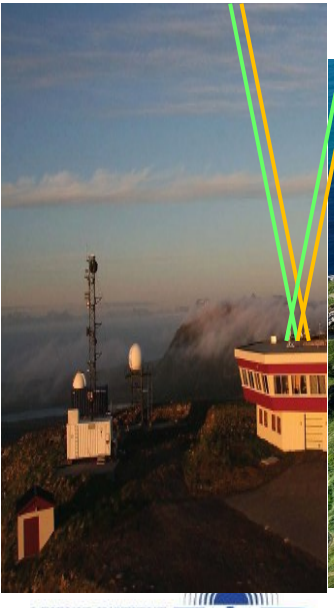
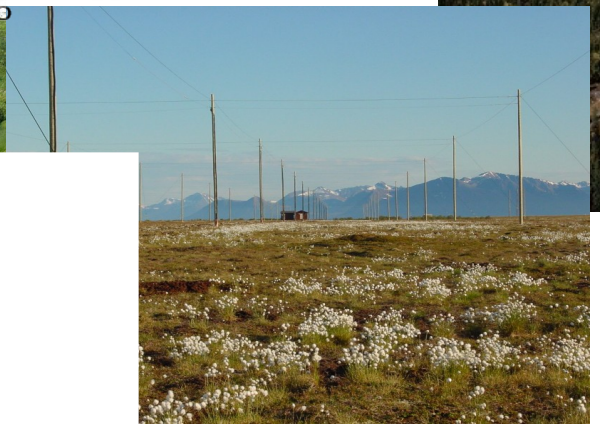


EISCAT

Lidar:
RMR-Lidar

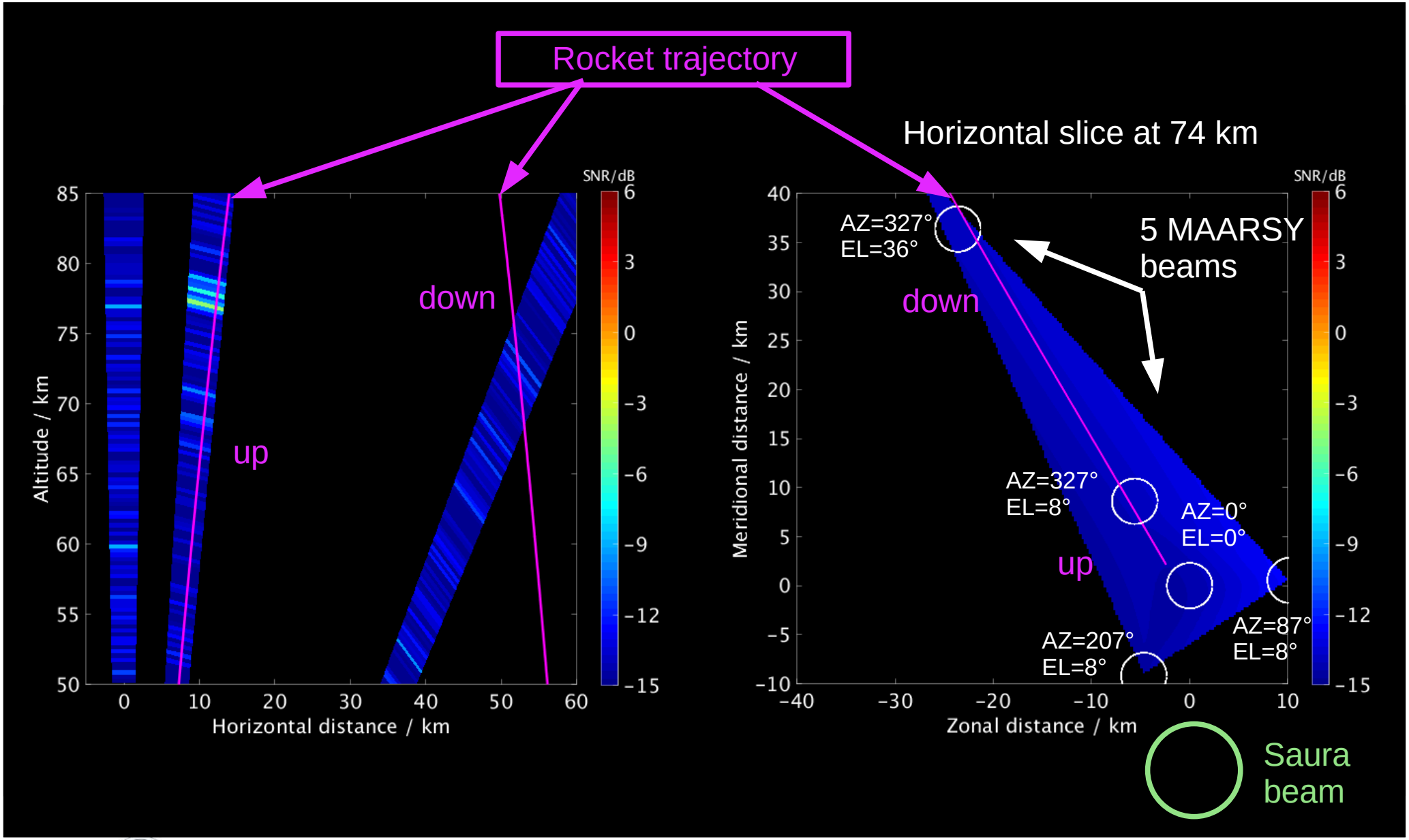


Radars:
MAARSY
Saura
SKiMET



ESRAD

Experiment geomerty

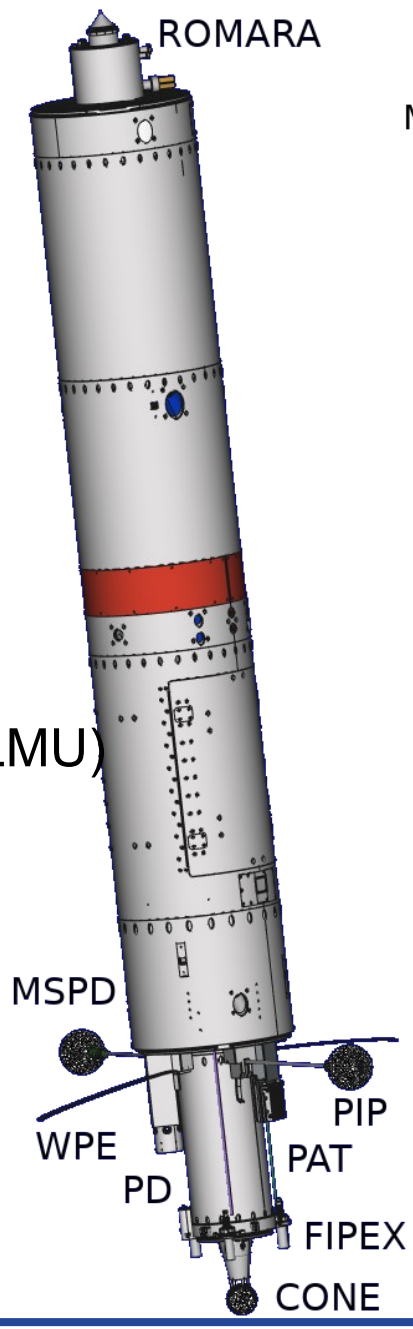


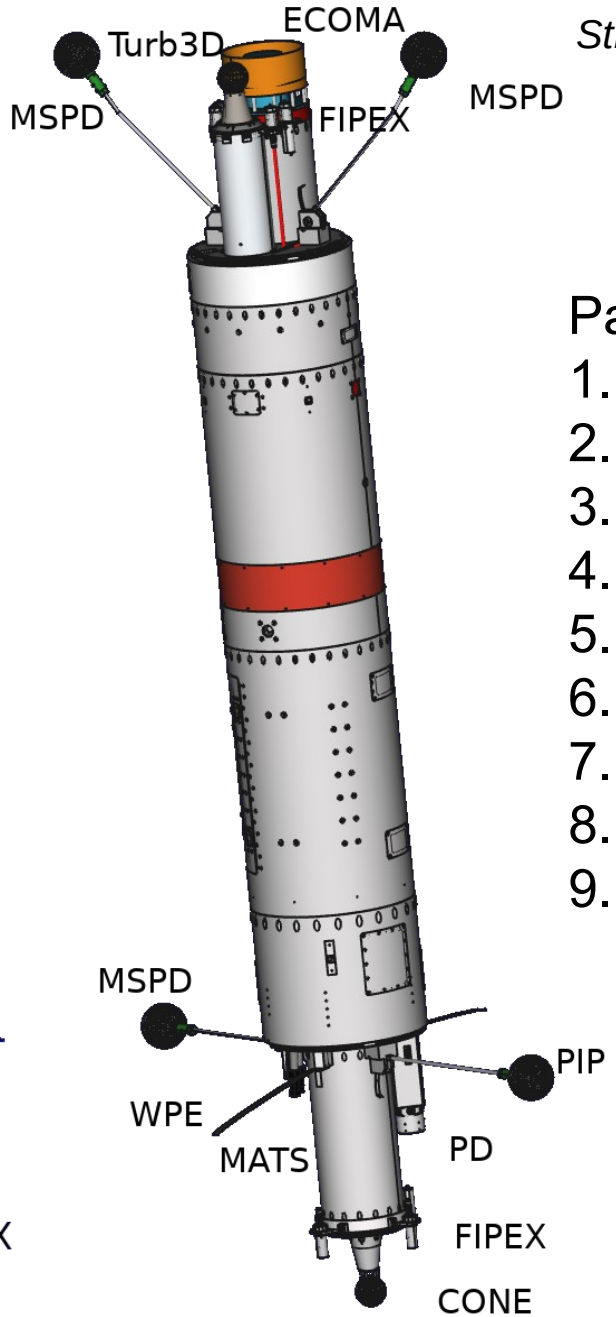
Latteck et al., ARS, 2019; Staszak et al., JASTP, 2021

PMWE payloads & instrumentation

Strelnikov et al., JASTP, 2021

Payload F**ion**a
1. CONE NP+EP (IAP)
2. MSPD (IAP)
3. Faraday cup (IAP)
4. Mass Spectrometer (LMU)
5. Faraday (TUG)
6. PIP (IAP)
7. FIPEX (IRS)
8. PaT (MISU)





Payload **Dust**in
1. CONE NP+EP (IAP)
2. MSPD (IAP)
3. Faraday cup (IAP)
4. ECOMA (LMU)
5. Turb3D (IAP)
6. Faraday (TUG)
7. PIP (IAP)
8. FIPEX (IRS)
9. MATS (MISU)

PMWE1F launch (2018-04-13, 9:44 UTC)

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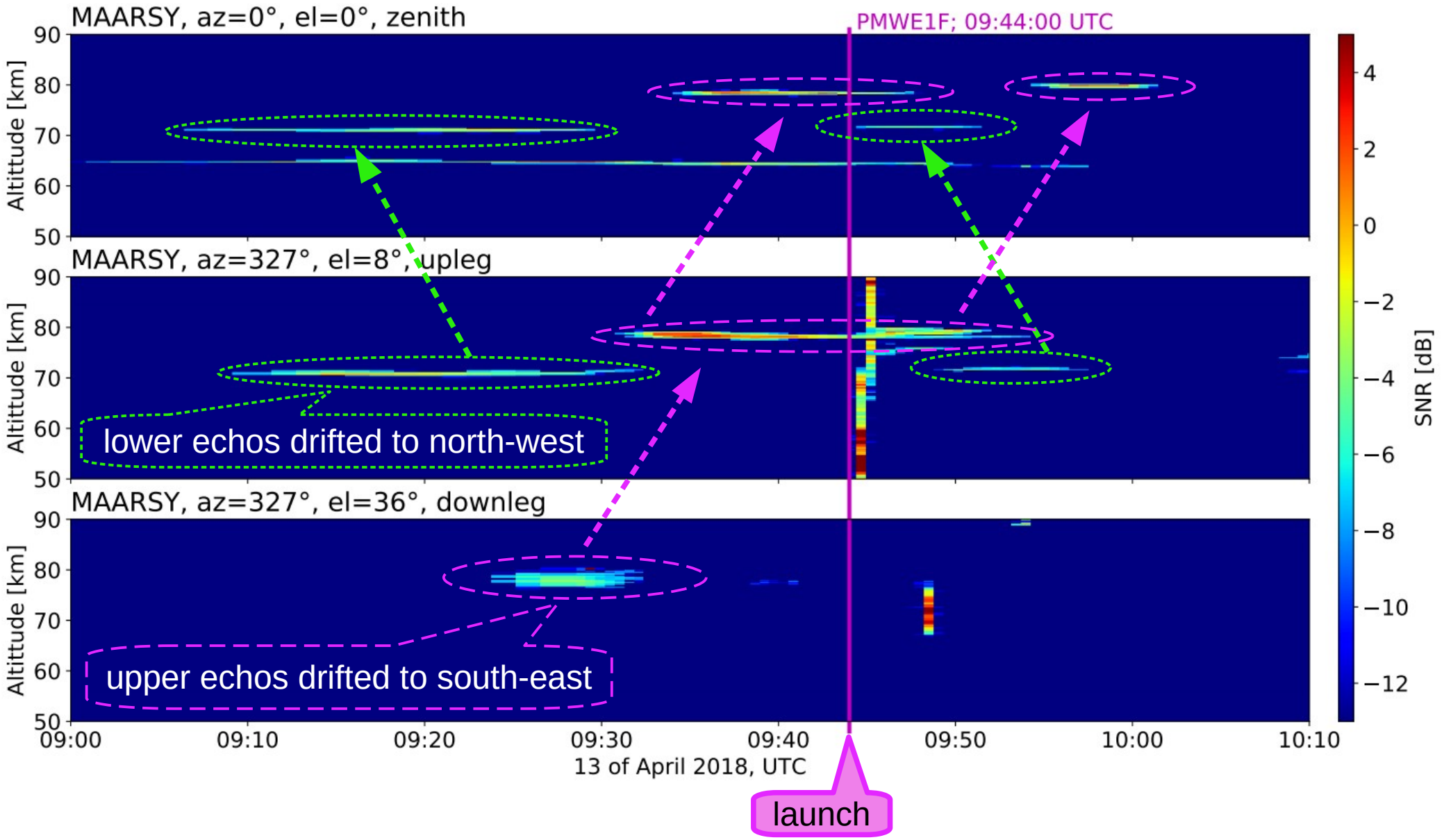

Strelnikov et al., JASTP, 2021; Staszak et al., JASTP, 2021

PMWE1D launch (2018-04-18, 13:00 UTC)

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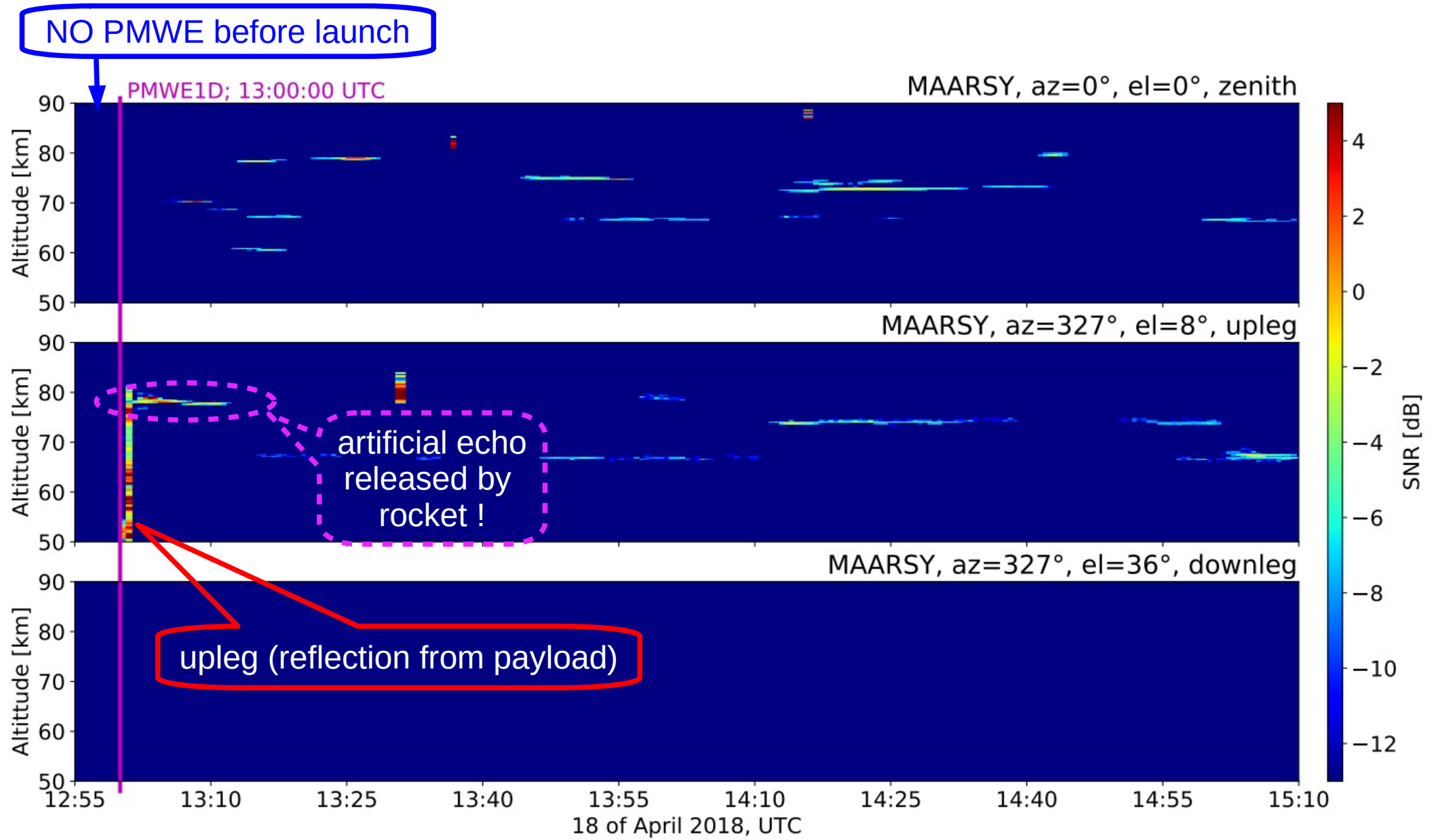

PMWE1F @78 km: winds vs waves

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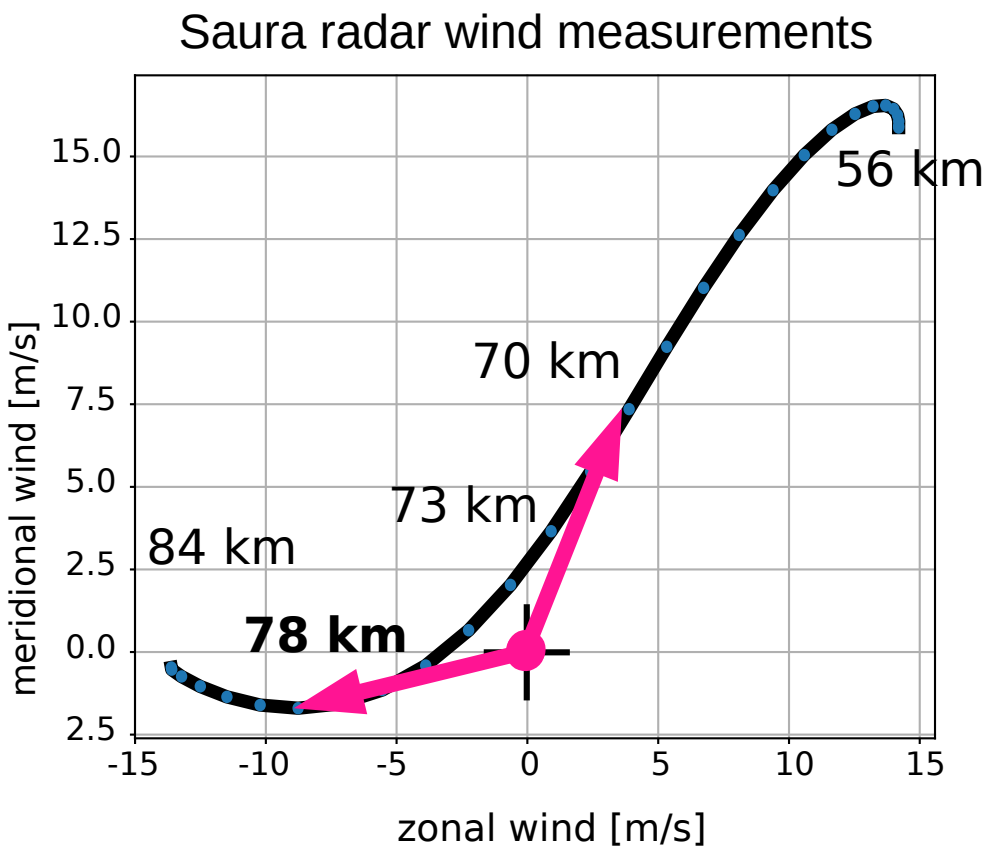

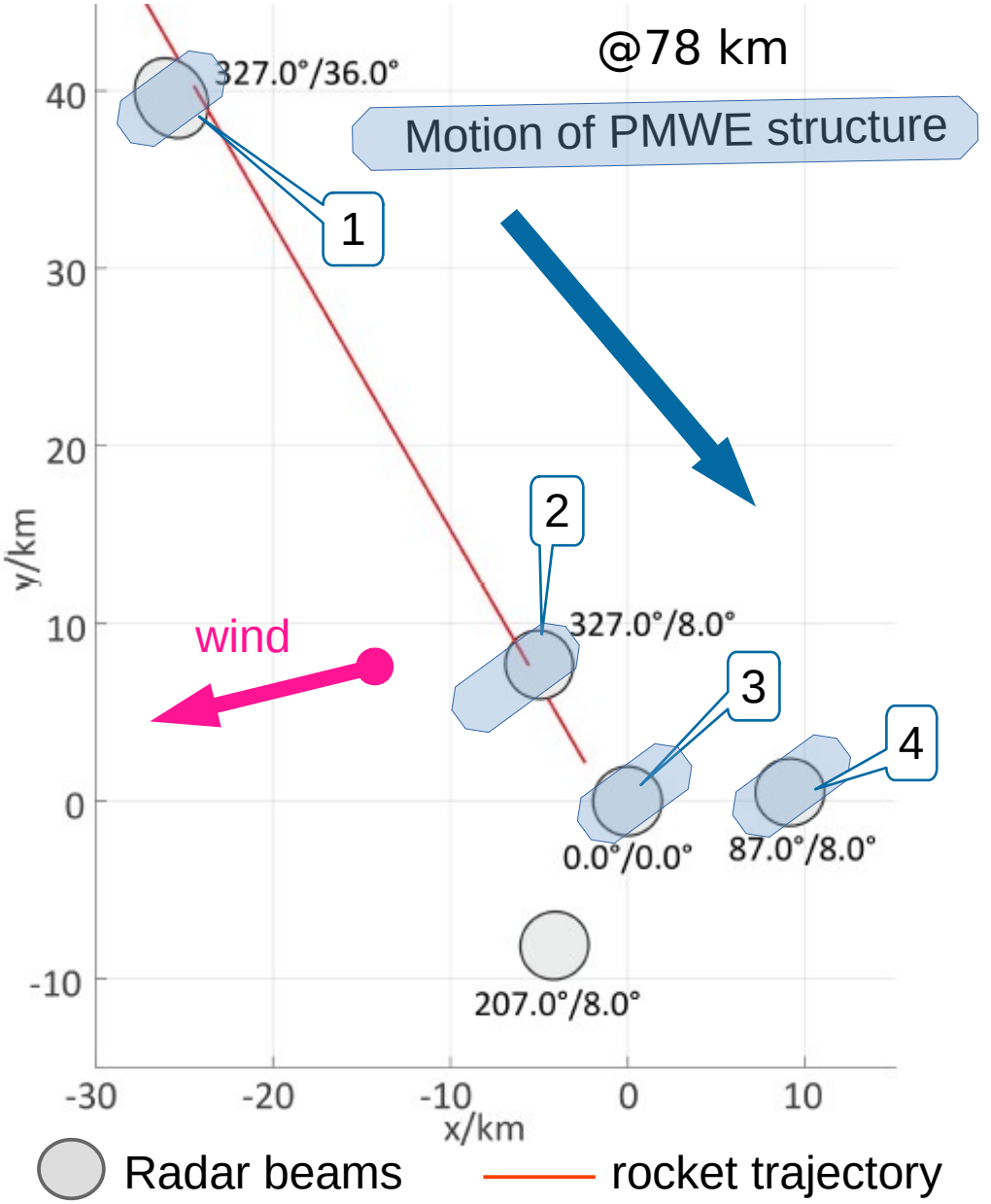

Almost opposite or perpendicular propagation directions (PMWE against wind) suggests: PMWE moved with (gravity) waves

Strelnikov et al., JASTP, 2021; Staszak et al., JASTP, 2021

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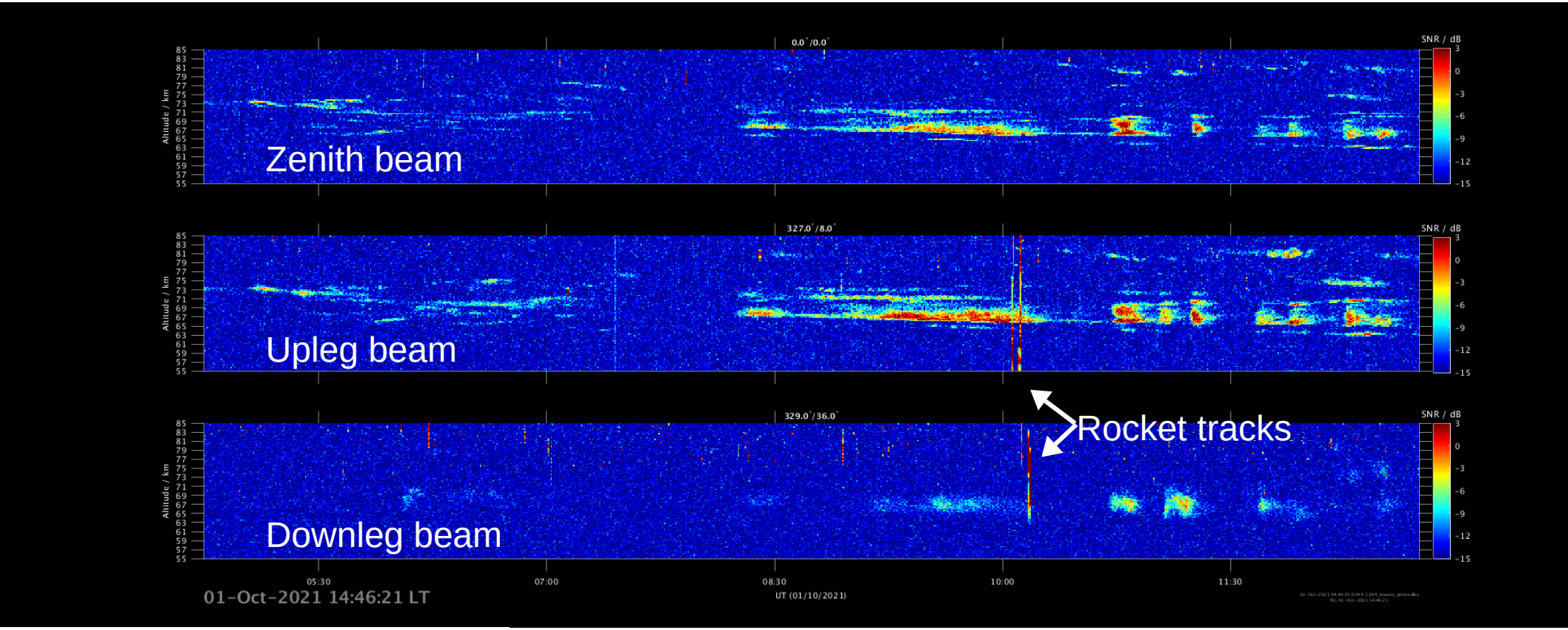
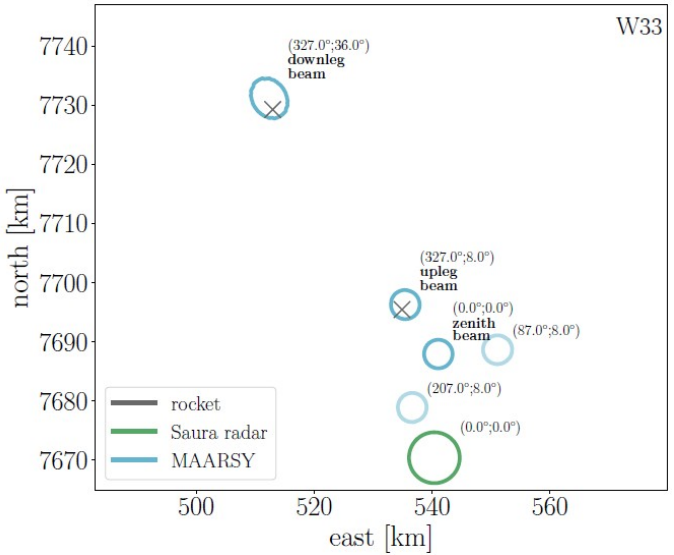
2nd campaign: Launch conditions





Strong PMWE in ALL radar beams
1. October 2021
Salvo: 2 instrumented rockets +
2 met-rockets

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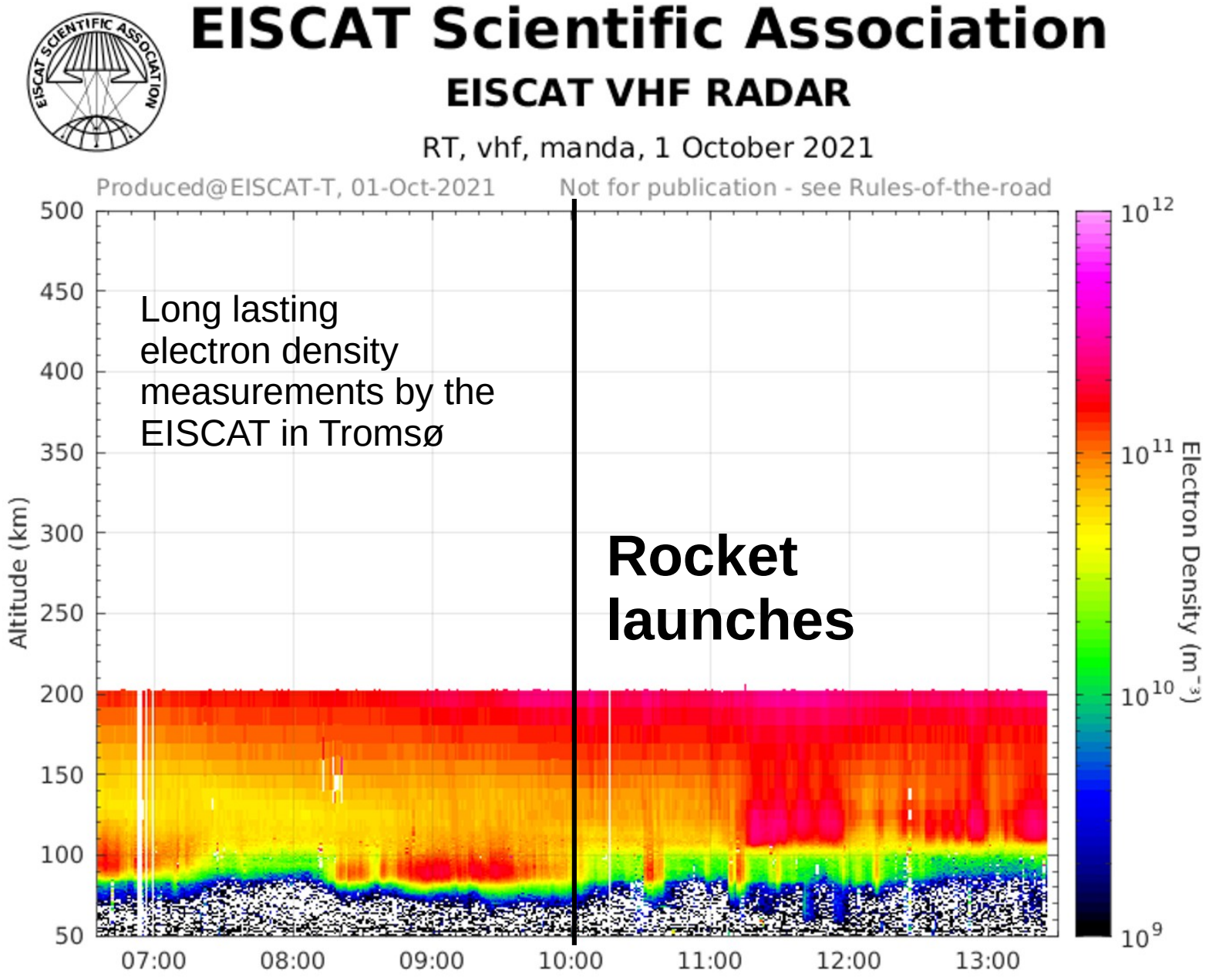
Ionization (N_e) triggers PMWE display



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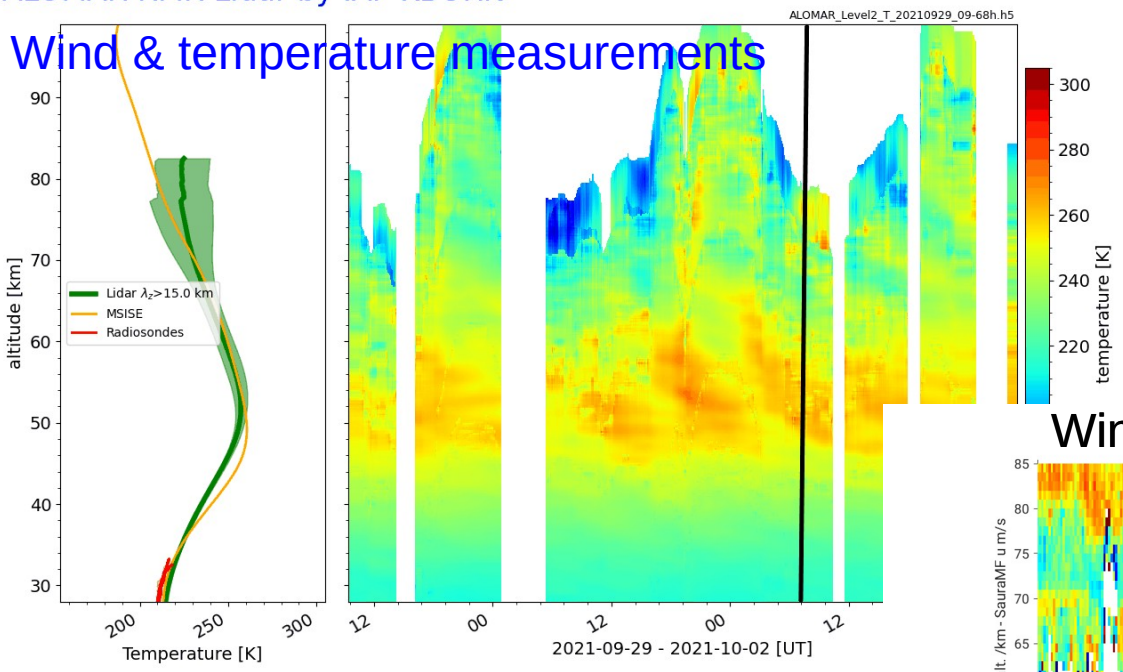
Extensive ground-based support

ALOMAR RMR-Lidar by IAP-KBORN

Wind & temperature measurements



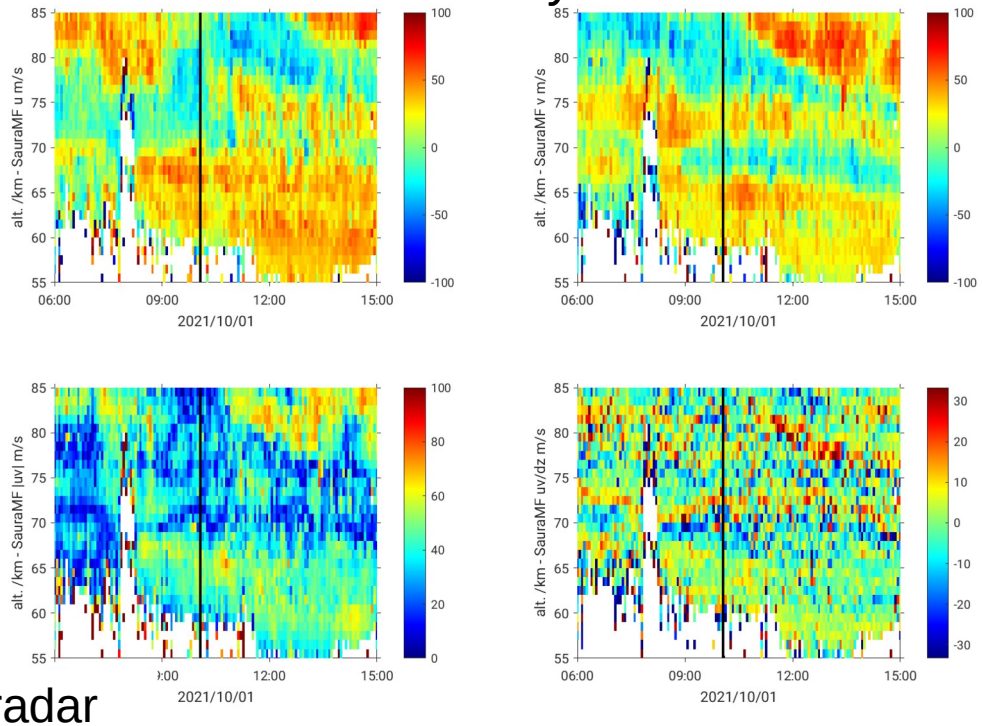
2021-09-29 09:25
2021-10-02 04:59
67.6 hours
Av_125m/1.05km

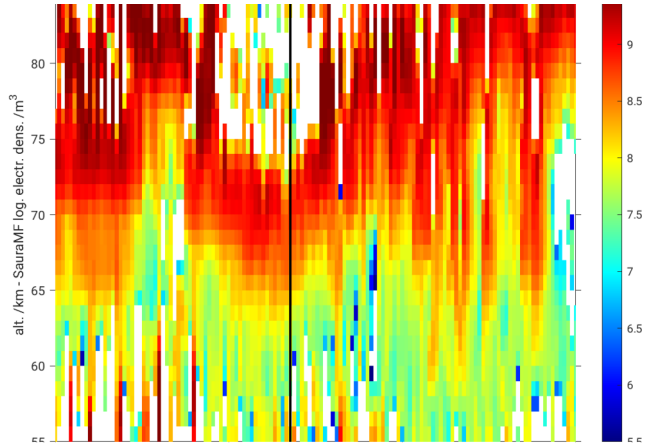
Stratopause:
257 K @ 51.9 km

dT/dz:
4.0 K/km @ 77.6 km
-2.0 K/km @ 78.4 km

Great set of measurements allows for detailed analysis of neutral dynamics
(e.g., GW, tides, dynamic stability)

Wind measurements by IAP Saura radar





Electron density measurements by IAP Saura radar

Main results:

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1) PMWE are created by neutral air turbulence
2) Turbulence is created by Gravity Waves (GWs) breakdown
3) PMWE are advected by GWs
4) Meteor Smoke Particles (MSPs or dust) of sizes ≤1 nm is always present in winter MLT
5) MSPs only make small effect on PMWE

1) – 3) makes PMWE a great tracer for neutral dynamics
and
motivated comprehensive GW measurements during PMWE-2 sounding rocket campaign: Detailed analysis will be published soon.

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Thank you all for your attention!