9. MIDDLE ATMOSPHERE COOPERATION/ SUMMER IN NORTHERN EUROPE (MAC/SINE) AND MAC/EPSILON

9.1 THE MAC/SINE AND MAC/EPSILON CAMPAIGNS

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Two major international campaigns dedicated to the study of middle atmosphere dynamics in high latitudes were successfully completed in 1987. MAC/SINE (Middle Atmosphere Cooperation/Summer in Northern Europe) was carried out during the period 7 June - 19 July, whereas MAC/Epsilon took place in the period 12 October - 15 November. In both campaigns a large number of ground-based and rocket techniques were used in a concerted effort to map the dynamical structure of the middle atmosphere over Northern Europe. Although the analysis of the observations has only just started, it is clear that a large and unique data set has been obtained, which we believe will provide new insight into the dynamical processes in this interesting region of the atmosphere. The paper will present a brief overview of the campaigns, their scientific aims, organization and structure.

Organization of MAC/SINE and MAC/Epsilon

Operation Center:	Andoya Rocket Range
Project Scientist:	Prof. E. V. Thrane
Deputy Project Scientist:	Prof. U. von Zahn
Technical Coordinator:	Mr. A. Gundersen
Logistics, Technical Management:	Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt eV., Koeln, Mr. O. Röhrig Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt E.V, Wessling, Mr. K. Zdarsky NASA/GSFC Wallops Flight Facility, Mrs. D. L. Frostrom Norwegian Space Center, Oslo, Mr. A. Gundersen
Sponsoring Organizations:	Bundesministerium für Forschung und Technologie, Bonn Deutsche Forschungsgemeinschaft, Bonn National Aeronautics and Space Administration, Washington, DC Norwegian Space Centre, Oslo National Agencies in the Participating Countries

Measurements of Dynamical Processes

In order to map the dynamical processes in the middle atmosphere we must be able to measure:

Wind speed, density, temperature and pressure as well as small fluctuations of these parameters.

The problem:

To find experimental methods that work where the density is 1/1000 000 of the air density at ground level. For studies of turbulence the accuracy must be better than 0.1%.

A solution:

Measurements of easily detectable trace constituents, such as positive ions.

Scientific goals:

To study dynamical processes, winds, waves and turbulence in the high latitude middle atmosphere.
To study the interaction between ionospheric/auroral phenomena and the nonionized upper atmosphere.
To study the effects of the ionosphere/middle atmosphere on radio wave propagation in high latitudes.

Experimental tools:

Rockets, SINE:
- 27 Falling spheres (Andoya)
- 28 Chaff (Andoya)
- 4 NASA instrumented rockets (Andoya)
- 12 USSR instrumented rockets (Heiss Island)
- 7 USSR instrumented rockets (Volgograd)
- 4 USSR instrumented rockets (Prof Zubov)

Rockets, Epsilon:
- 5 European instrumented rockets (built in Norway)
- 8 NASA instrumented rockets
- 12 Falling spheres (Andoya)
- 9 chaff (Andoya)
- 18 USSR instrumented rockets (Heiss Island)
- 17 USSR instrumented rockets (Volgograd)

Rocket launches from Andoya Rocket Range during MAC/SINE

Regular met.rocket firings Mondays, Wednesdays and Fridays at 1100 h UT
In addition, several salvos were launched to study specific phenomena:

Chaff Salvo 1:	24 June 1987
Chaff Salvo 2:	26 June 1987
Chaff Salvo 3:	1 July 1987
Turbulence/Gravity Wave Salvo	14 July 1987
EISCAT Salvo	15 July 1987
Sodium/Chaff Salvo	15 July 1987

GROUND-BASED EXPERIMENTS IN MAC/EPSILON REV. 9 June 87

EXPERIMENT	OBSERVED PARAMETERS	LOCATION	REAL TIME	OPERATION
PARTIAL REFLECTION	e^- DENSITY TURBULENCE	RAMFJORDMOEN	N Y	CD
PRE DRIFT	WINDS	RAMFJORDMOEN	Y	C
PARTIAL REFLECTION	TURBULENCE	VOLGOGRAD	N	C
SOUSY VHF RADAR	TURBULENCE WINDS	BLEIK	Y N	CD
EISCAT	e^- DENSITY, λ WINDS	RAMFJORDMOEN	N Y	B
MS-RADAR	WINDS	SASKATOON	N	C
GLOBMET	WINDS	USSR (7x)	N	C
METEOR RADAR	WINDS	VOLGOGRAD	N	C
HF-CIRCUIT	PROPAGATION CONDITIONS	ANDENES-ALTA	N	C
IONOSONDES	IONOSPHERIC CONDITIONS	ANDENES, RAMFJORDMOEN	Y	A
A1-ABSORPTION	ABS. 2.2 MHz	VOLGOGRAD	N	C
RIOMETERS	ABSORPTION	ANDENES, FINLAND (9x), KIRUNA (KGI), RAMFJORDMOEN	Y	C
MAGNETOMETERS	GEOMAGNETIC CONDITIONS	ANDENES, FINLAND (Nx), KIRUNA (KGI), RAMFJORDMOEN	Y	C
UB LIDAR	TEMPERATURE NA-DENSITY, DENSITY	ANDENES	N Y	CS
UI LIDAR	NA-DENSITY, WINDS	LONGYEARBYEN	N	CS
CNRS LIDARS	DENSITY, TEMPERATURE	SKIBOTN, ON SHIP	N	CS

A EVERY 20 MINUTES
B SOME(10?) NIGHTS 15-21 UT
C CONTINUOUS
CD CONTINUOUS DURING COUNTDOWNS
CS CONTINUOUS WHEN CLEAR SKY

GROUND-BASED EXPERIMENTS IN MAC/EPSILON (CONT'D)
REV. 29 MAY 87

EXPERIMENT	OBSERVED PARAMETERS	LOCATION	REAL TIME	OPERATION
IR MERIDIAN SCANNER	?	ANDENES	N?	CS
IR INTERFEROMETER (LOWE)	AURORAL, AIRGL.EMISS., TEMPERATURE?	SKIBOTN?	N?	CS
IR INTERFEROMETERS (WARE)	AURORAL, AIRGL.EMISS., TEMPERATURE?	KIRUNA (KGI)	N?	CS
SPECTROMETERS (WITT)	AURORAL, AIRGL.EMISS.	ANDENES, KIRUNA (KGI)	Y	CS
PHOTOMETER (PETERSON)	AURORAL, AIRGL.EMISS.	SKIBOTN?	Y	CS
PHOTOMETERS (WITT)	AURORAL, AIRGL.EMISS.	ANDENES	Y	CS
PHOTOMETER (ARR)	AURORAL, AIRGL.EMISS.	ANDENES	Y	CS
IMAGERS (2 PETERSON)	AURORAL, AIRGLOW STRUCTURE	SKIBOTN?	Y?	CS
IMAGER (TAYLOR)	AURORAL, AIRGLOW STRUCTURE	SODANKYLÄ	Y?	CS
ALL-SKY CAMERA	AURORAL STRUCTURE	ANDENES	N	CD
ALL-SKY CAMERA (PETERSON)	AURORAL STRUCTURE	KIRUNA (KGI)	N?	CS
VIDEO CAMERA (PETERSON)	AURORAL, AIRGL. STRUCTURE?	SKIBOTN?	Y?	CS
FABRY-PEROT ETALONS (3 + 1 OH + 1 TRIPLE)	WINDS	KILPISJÄRVI, KIRUNA (KGI), SVALBARD	N	CS
STEREO OH TV (TAYLOR)	WAVES	IVALO-SODANKYLÄ	Y	CS
ALL-SKY IMAGING (REES)	OH-VARIABILITY	KIRUNA (KGI)	N?	CS

CD CONTINUOUS DURING COUNTDOWNS
CS CONTINUOUS WHEN CLEAR SKY

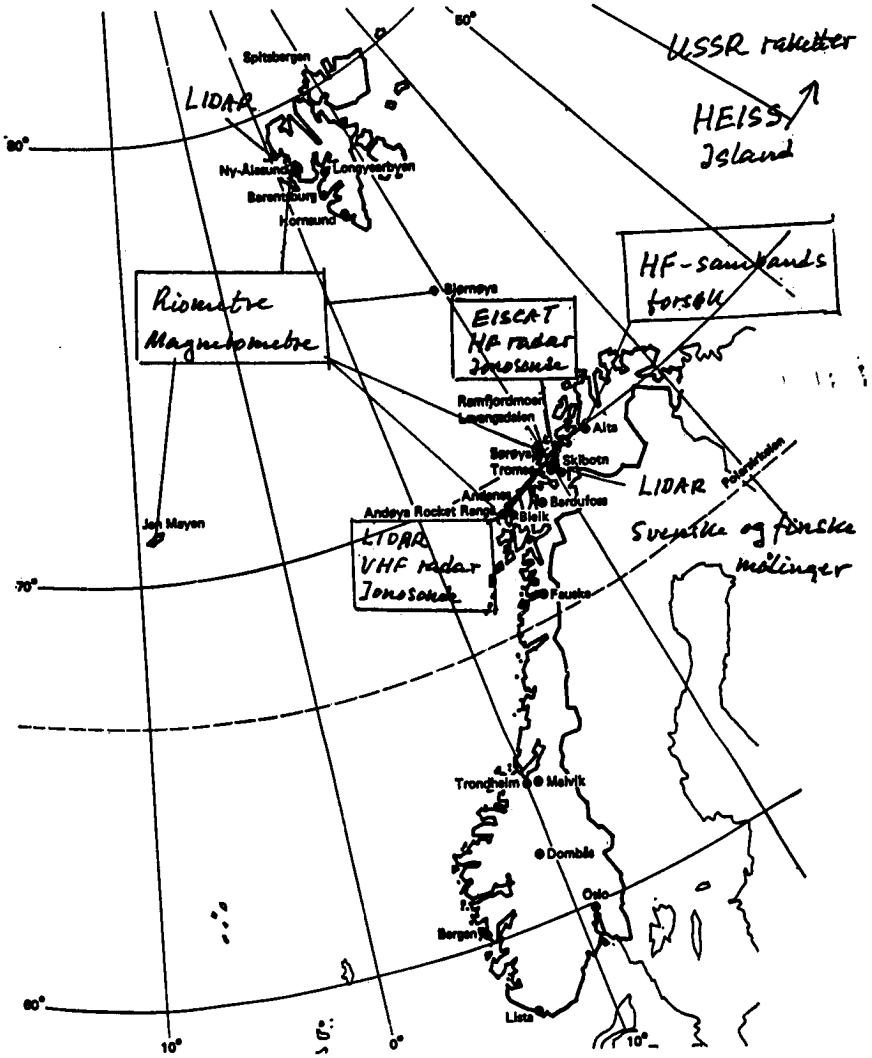

Figure 1. More than 50 ground-based instruments.

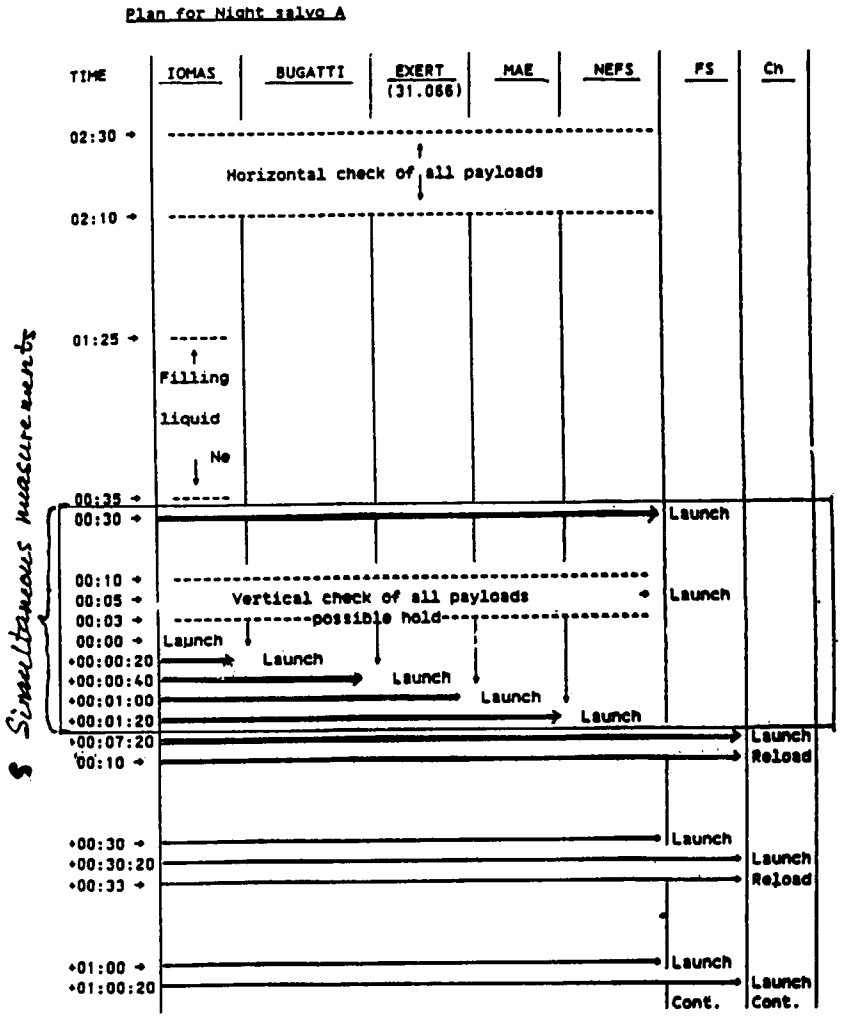

Figure 2. Simultaneous measurements made with 24 rocket experiments.

OVERVIEW OF THE MAC/EPSILON CAMPAIGN

Four salvos were launched during the campaign:

Day Salvo: 15 October
- Launch criteria:
  - Presence of turbulence (PRE, SOUSY)
  - Presence of gravity waves (PRE, EISCAT, LIDAR)
  - Riometer absorption between 0.2 and 2 dB
  - Clear sky sufficient for LIDAR results
- All launch criteria fulfilled

Night Salvo A: 21 October
- Launch criteria:
  - Presence of turbulence (PRE, SOUSY)
  - Presence of gravity waves (PRE, EISCAT, LIDAR)
  - Riometer absorption between 0.2 and 2 dB
  - Clear sky sufficient for LIDAR results
- All launch criteria fulfilled

Night Salvo A1: 28 October
- Launch criteria:
  - Presence of turbulence (PRE, SOUSY)
  - Presence of gravity waves (PRE, EISCAT, LIDAR)
  - Riometer absorption between 0.2 and 2 dB
  - Presence of pulsating aurora
  - Clear sky sufficient for LIDAR results
- All launch criteria fulfilled

Night Salvo B: 12 November
- Modified launch criteria
  - Presence of turbulence (PRE, SOUSY)
  - Presence of gravity waves (PRE, EISCAT, LIDAR)
  - Riometer absorption between 0.2 and 2 d
- Modified launch criteria fulfilled.

HOW DID IT GO?

The data analysis is progressing well!

MAC/SINE

Very interesting observations were made by rockets and ground-based instruments. Summer conditions in high latitudes were mapped in greater detail than previously. Of particular importance are layers observed near the mesopause.

47 out of 55 met rockets from Andoya worked, success rate 87%

All instrumented rockets from Andoya worked, success rate 100%

The ground-based instruments performed well.

MAC/Epsilon

Four salvos were launched from Andoya. The launch criteria were fulfilled for three of these. The last salvo was launched under modified conditions. A very good series of measurements of turbulence was obtained.

18.5 out of 21 met rockets from Andoya worked, success rate 88%

Out of 55 rocket instruments launched from Andoya 51 worked, success rate 93%

Most ground-based instruments gave good results.