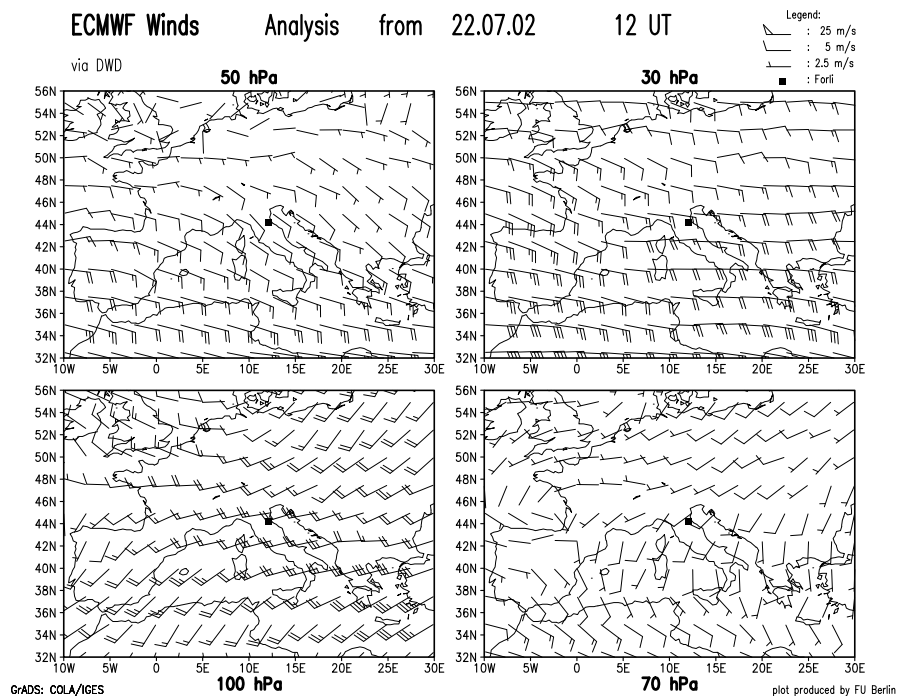


# METEOROLOGY FOR VALIDATION

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Meteorological Institute, Free University Berlin, Germany

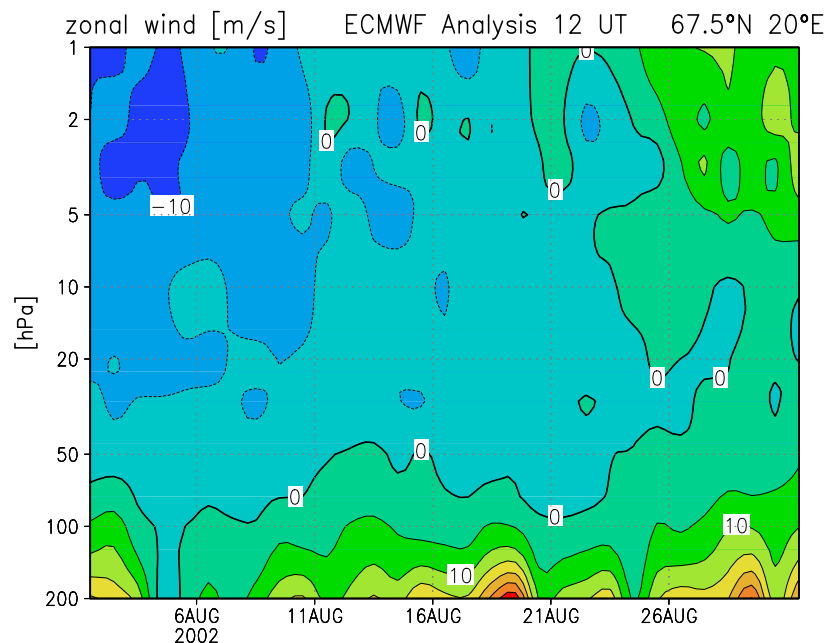
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1. Support of Validation Campaigns
2. Short Overview on the Arctic Winter 2002/03
3. Trajectory Calculations – Method and some Examples

## Support of Validation Campaigns

- Provision of meteorological fields (temperature, geopotential heights, winds, potential vorticity), based on ECMWF analyses and forecasts
- Trajectory calculations for matches with the ENVISAT overpasses
- Daily meteorological briefings at the campaign sites or ...
- Provision of the requested informations on a ftp-server

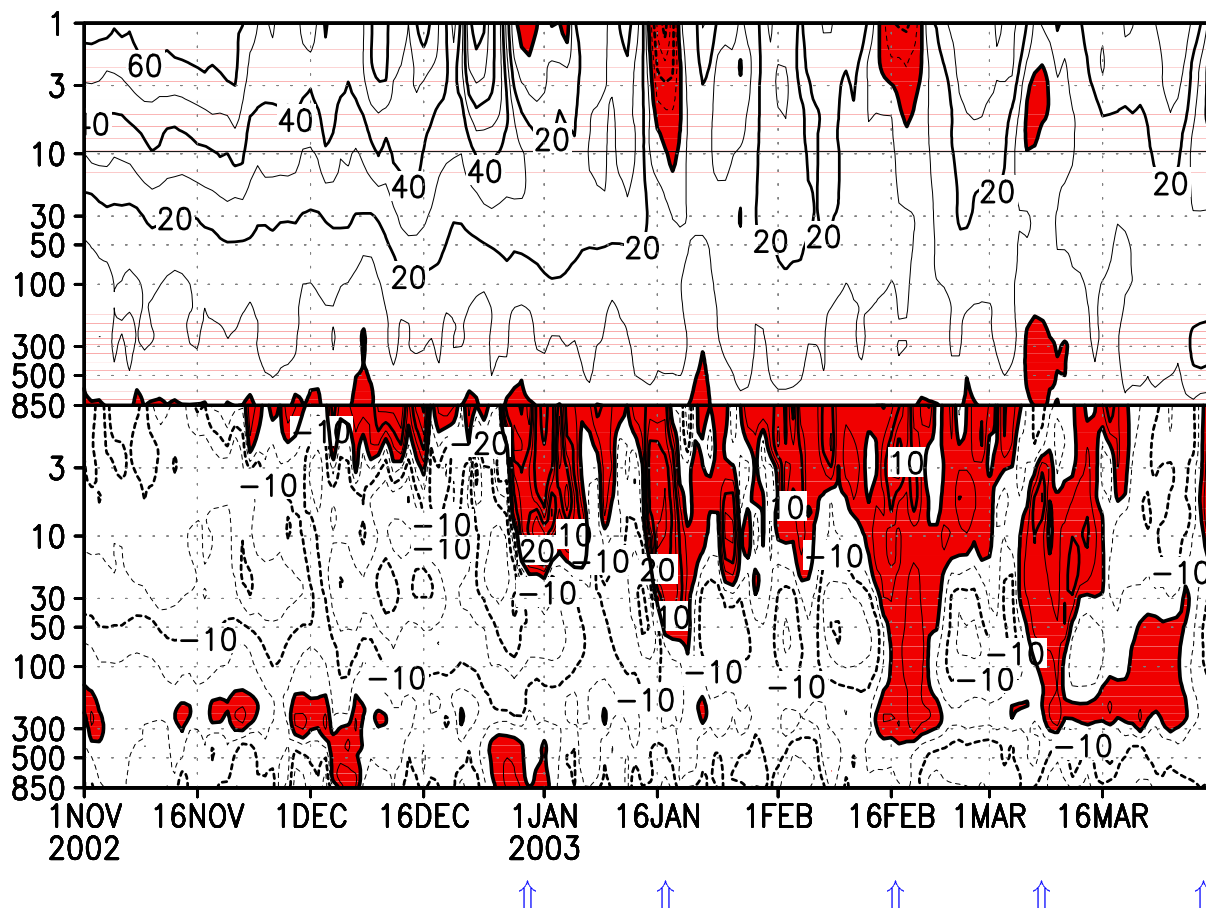


Time-height-section of zonal winds at Kiruna in August 2002

### Campaigns

July 2002	Forli	M55
Aug 2002	Kiruna	LPMA/DOAS
Sep/Oct 2002	AsA	TRIPLE, MIPAS-B
Oct 2002	Forli	M55
March 2003	Kiruna	LPMA/DOAS, TRIPLE, MIPAS-B, M55
Jun/Jul 2003	Kiruna	TRIPLE, MIPAS-B

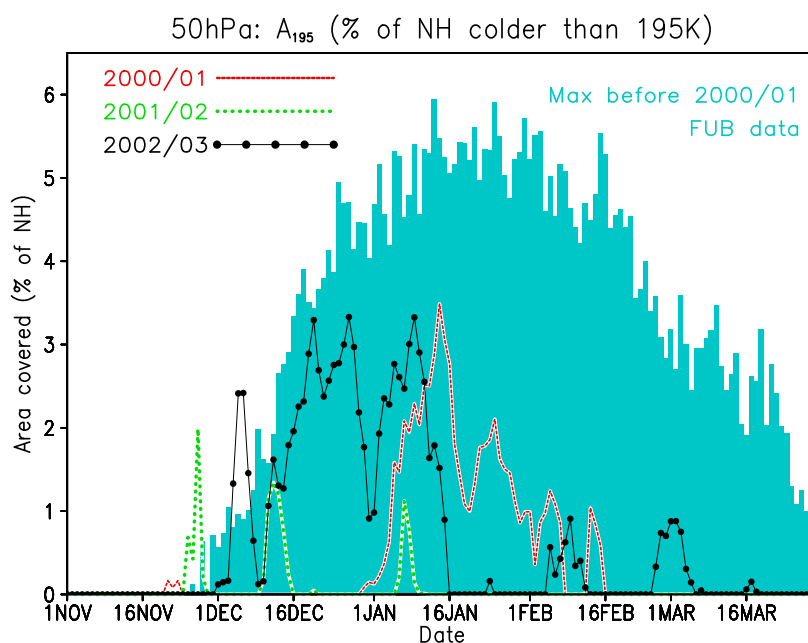
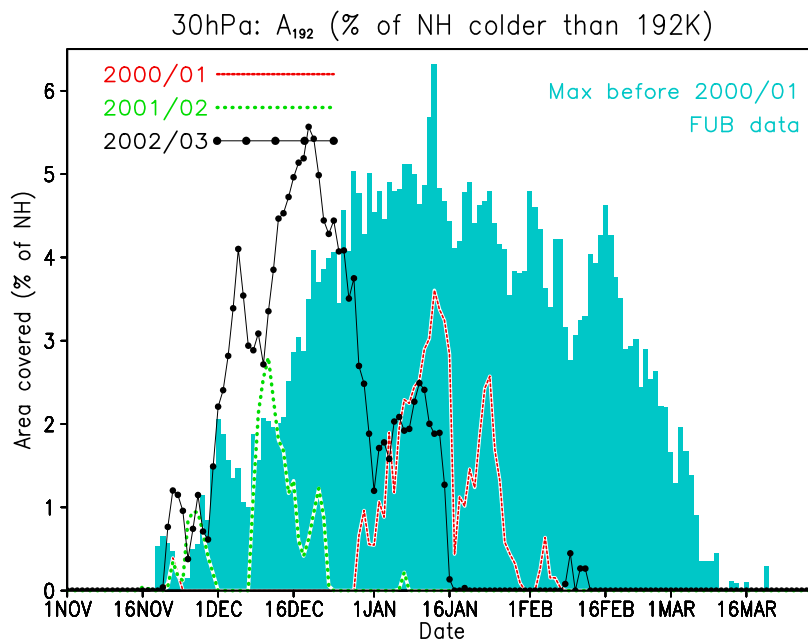
## General Development



Time-height sections of zonal mean zonal wind (m/s) at 60°N and of the temperature gradient (K) between 60°N and the Northpole from ECMWF analyses (easterly winds and positive temperature gradients are in red)

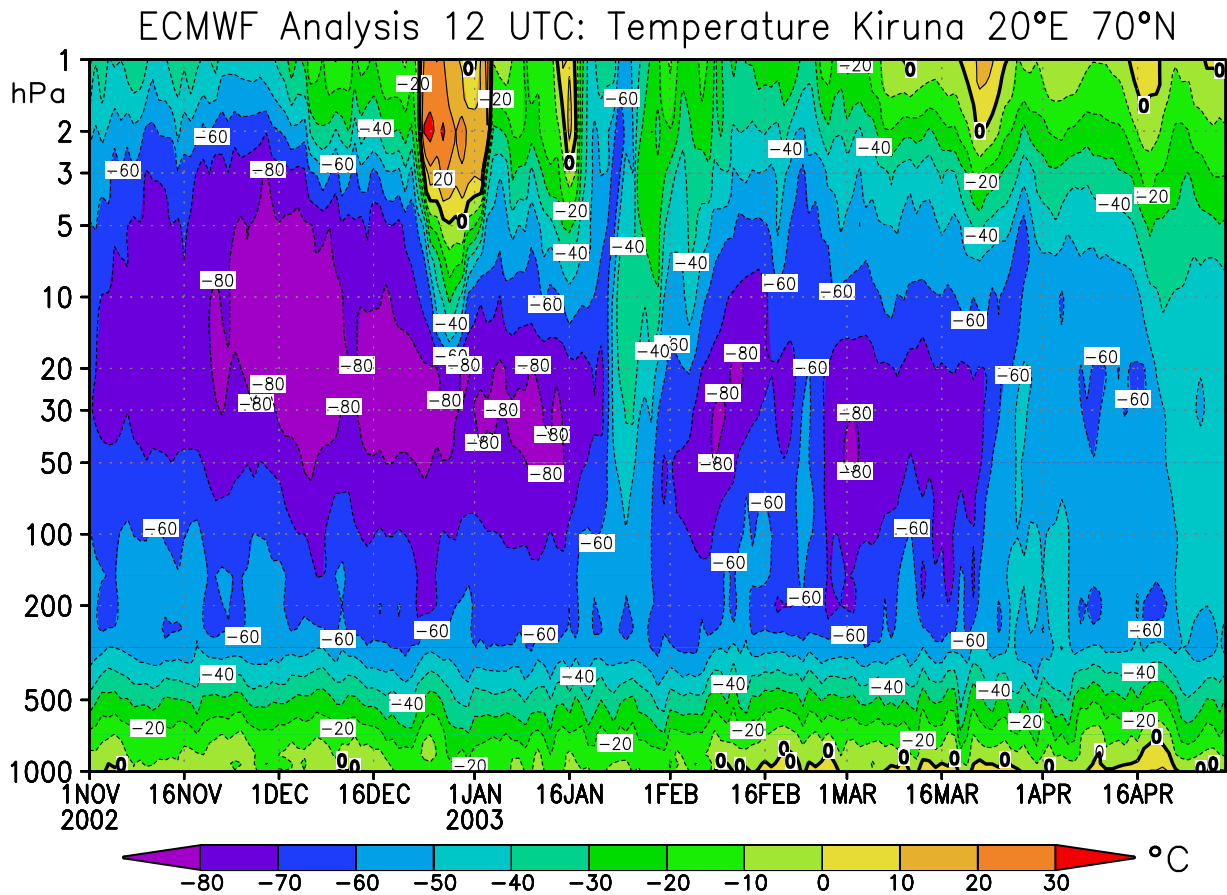
- Extremely Cold Early Winter
- Minor Warming in December
- Major warming in January
- Minor Warmings in February and March
- Final Warming in March/April

## ECMWF PSC Areas



- Extremely large areas of possible PSC formation occurred at 30 hPa for more than one month in early winter
- Only small areas occurred later in the winter, at 50 hPa for short times until mid-March

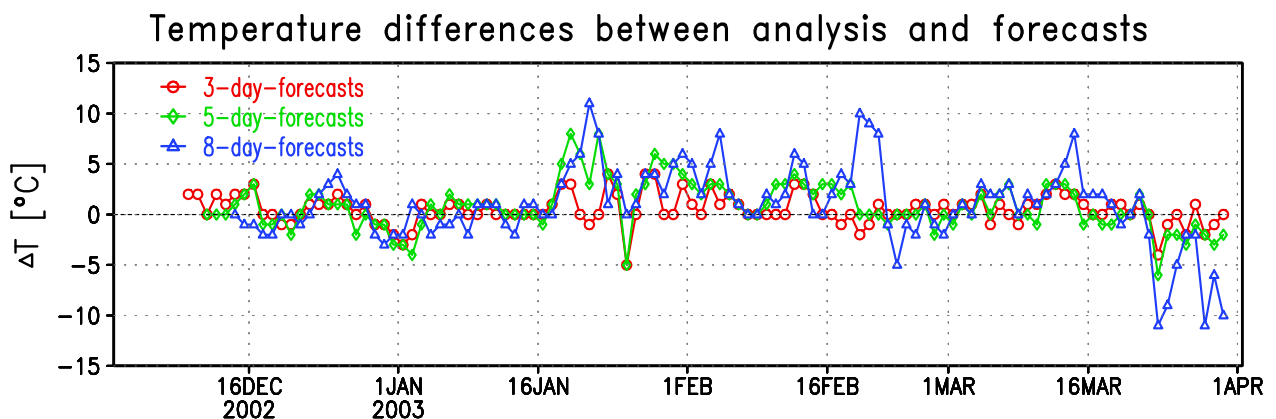
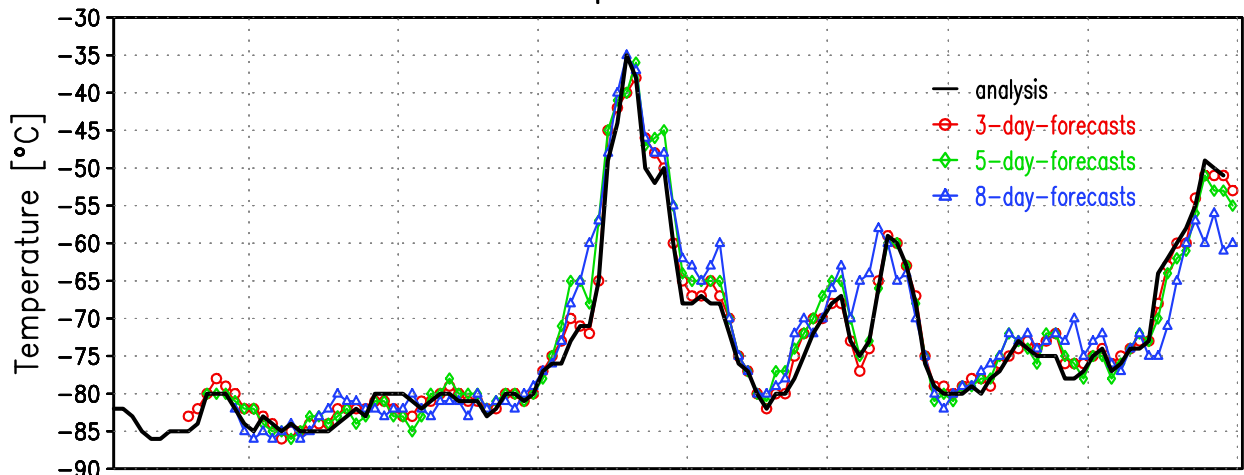
## Temperatures at Kiruna



- Coldness in early winter
- not much disturbed by the upper stratospheric warming in December
- interrupted by the major warming in January
- but cold again in late winter
- and beginning of the final warming at the end of March

## Temperatures at Kiruna

ECMWF 30-hPa in Winter 2002/03 at Kiruna  
Temperatures



← SOLVE 2/VINTERSOL/ESABC →

← ESABC/SOLVE 2 →

- ECMWF 3-day-forecasts performed well with 71% of all forecasts within the range of  $\pm 1$  K
- 5-day- and 8-day-forecasts exhibit only 50% and 39%, respectively,
- and have the tendency to speed up the temperature increase during the warming pulses
- The 8-day-forecasts completely failed in showing the timing and extent of the final warming.

## Trajectory Calculations

### Method for Balloon Flight Planning

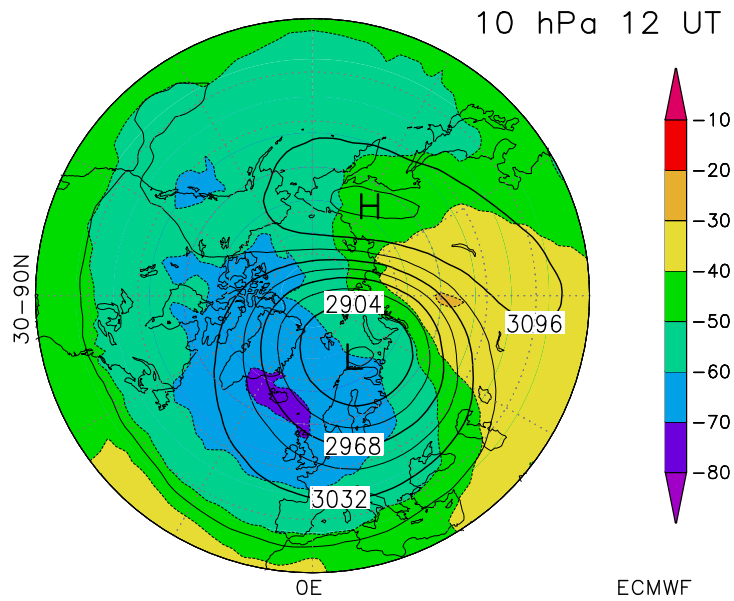
- Start of backward and forward trajectories at the predicted balloon measurement points
  - being the predicted balloon trajectory for in-situ instruments
  - depending on the observational geometry for remote sensing instruments
- Search for satellite measurement points fulfilling the matching criteria:
  - not more than one hour time delay
  - not more than 500 km distance from the centre of the satellite scan
- Test of these criteria for each individual air mass trajectory

### Trajectory Model

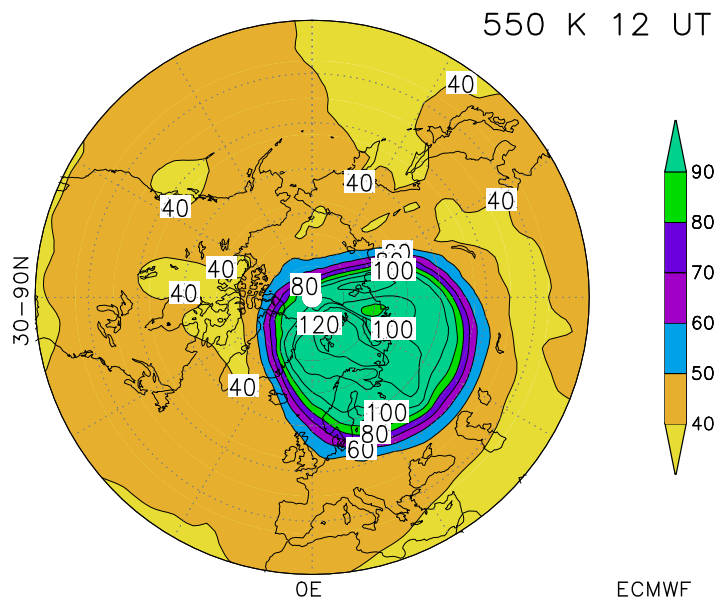
- ECMWF data,  $2.5^\circ \times 2.5^\circ$ , every 6 hours, analyses and forecasts
- Calculation on isentropic levels from the surface up to 1400 K with interpolation between the levels
- Internal time step: 10 minutes
- Newtonian cooling for diabatic heating rates
- Forward and backward trajectories
- Altitude of start points given as potential temperature, pressure, height above surface or height above sea level
- Results are saved for each hour

# LPMA/DOAS Flight, 04.03.03, Kiruna

Geopotential Height [gdam], Temperature [ $^{\circ}$ C]



Potential Vorticity [ $10^{-6}$  K m<sup>2</sup>/kg s]

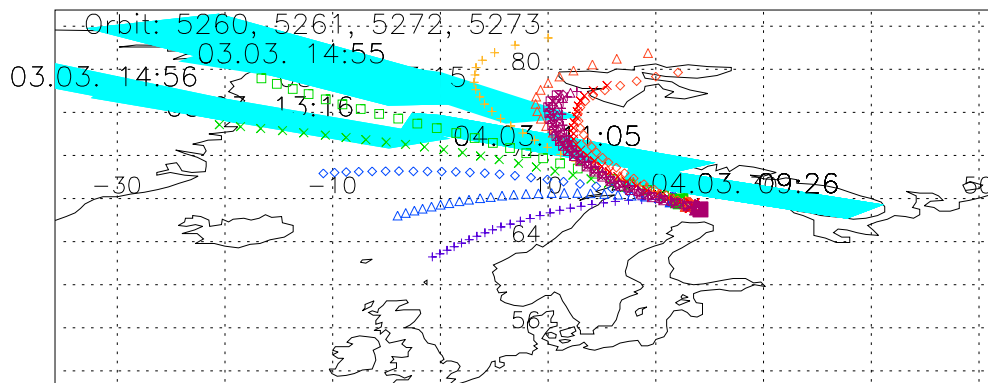




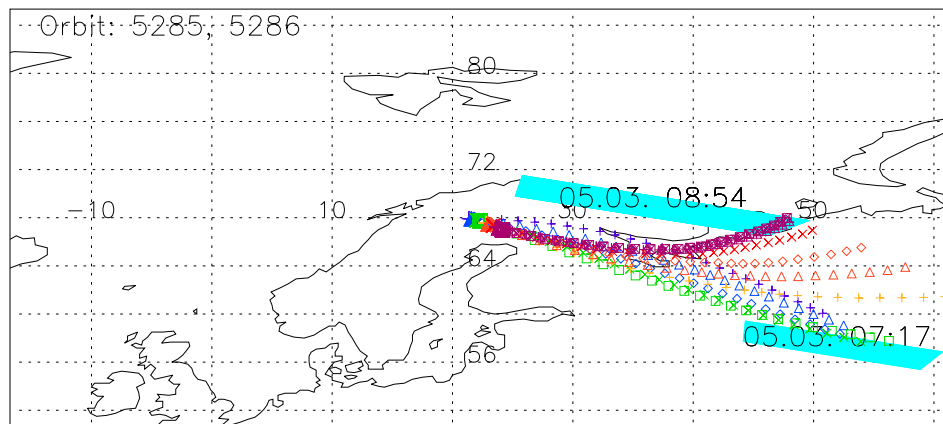
# LPMA/DOAS Flight, 04.03.03, Kiruna

Trajectories started at analysed balloon measurement points and colocated LIMB scans of Sciamachy

1 day backward trajectories - balloon ascent, Scia LIMB



1 day forward trajectories - balloon ascent, Scia LIMB



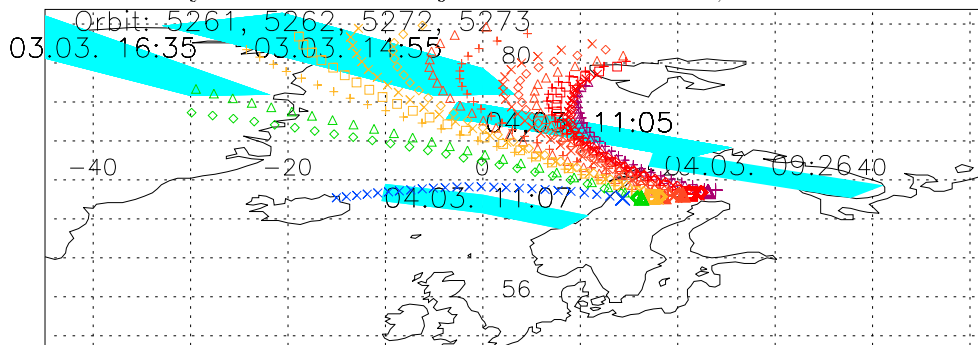
start time and altitude

▲	04.03.03 14:30 UT	26.8 km	■	04.03.03 15:30 UT	31.4 km
+	04.03.03 14:20 UT	24.4 km	×	04.03.03 15:30 UT	31.3 km
□	04.03.03 14:00 UT	19.5 km	◇	04.03.03 15:20 UT	31.3 km
×	04.03.03 13:50 UT	16.9 km	△	04.03.03 15:10 UT	31.2 km
◇	04.03.03 13:40 UT	14.1 km	+	04.03.03 15:00 UT	31.1 km
△	04.03.03 13:30 UT	11.8 km	×	04.03.03 14:50 UT	30.5 km
+	04.03.03 13:20 UT	9.1 km	◇	04.03.03 14:40 UT	29.0 km

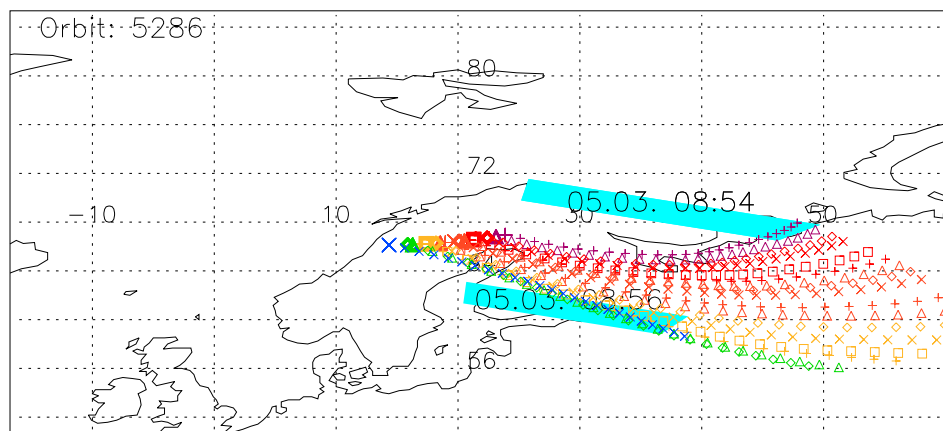
# LPMA/DOAS Flight, 04.03.03, Kiruna

Trajectories started at analysed balloon measurement points and colocated LIMS scans of Sciamachy

1 day backward trajectories - sunset, Scia LIMB



1 day forward trajectories - sunset, Scia LIMB

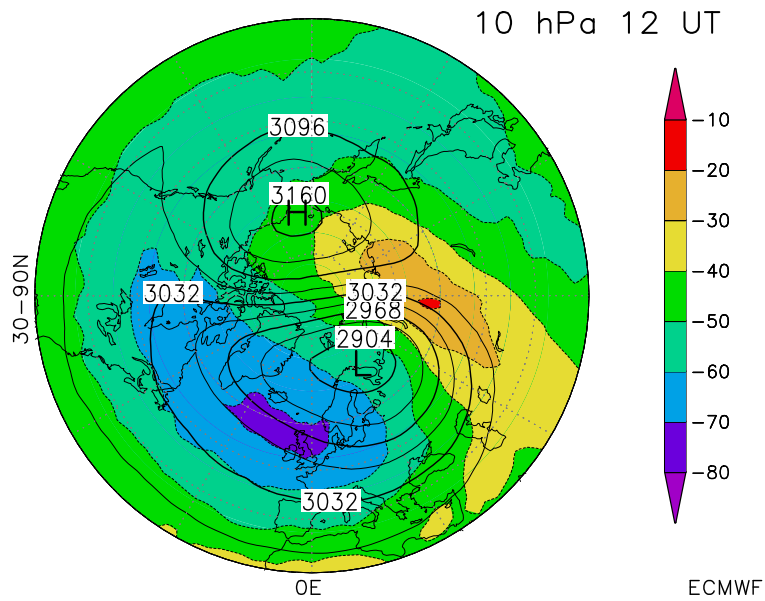


start time and altitude

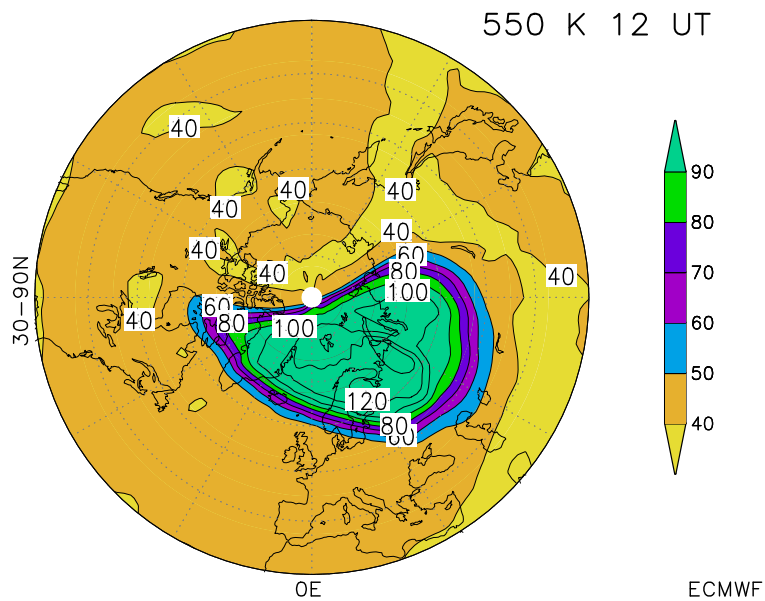
×	04.03.03 15:50 UT	27.7 km	×	04.03.03 16:20 UT	13.6 km
◇	04.03.03 15:50 UT	28.2 km	◇	04.03.03 16:10 UT	18.5 km
△	04.03.03 15:50 UT	28.8 km	△	04.03.03 16:10 UT	19.7 km
+	04.03.03 15:50 UT	29.3 km	+	04.03.03 16:00 UT	21.8 km
□	04.03.03 15:50 UT	29.7 km	□	04.03.03 16:00 UT	22.8 km
×	04.03.03 15:40 UT	30.4 km	×	04.03.03 16:00 UT	23.7 km
◇	04.03.03 15:40 UT	30.7 km	◇	04.03.03 16:00 UT	24.6 km
△	04.03.03 15:40 UT	31.0 km	△	04.03.03 16:00 UT	25.5 km
+	04.03.03 15:30 UT	31.4 km	+	04.03.03 16:00 UT	26.3 km

# Triple Flight, 06.03.03, Kiruna

Geopotential Height [gdam], Temperature [°C]



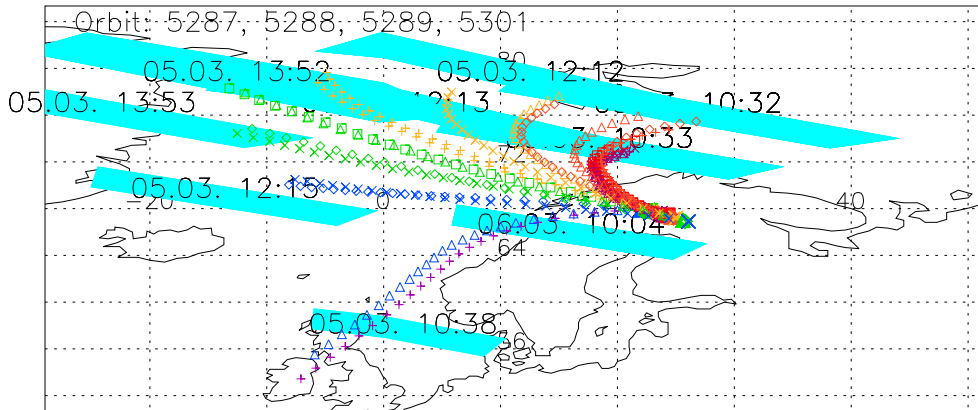
Potential Vorticity [ $10^{-6}$  K m<sup>2</sup>/kg s]



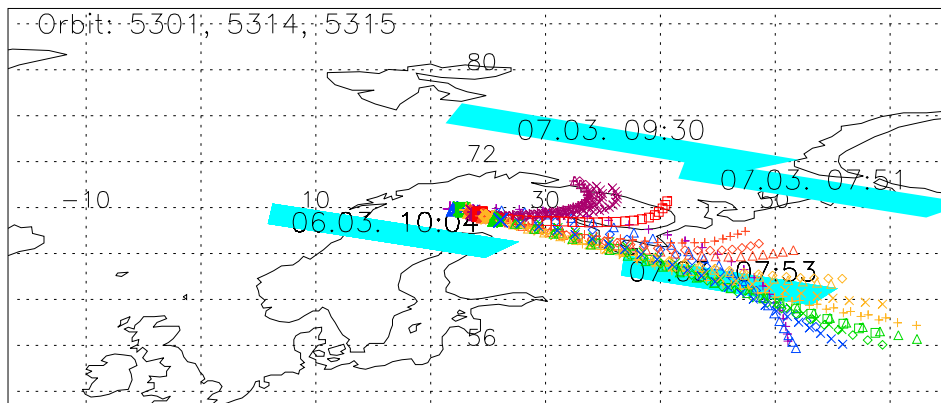
# Triple Flight, 06.03.03, Kiruna

Trajectories started at predicted balloon measurement points and colocated LIMB scans of Sciamachy

1 day backward trajectories - Scia LIMB



1 day forward trajectories - Scia LIMB

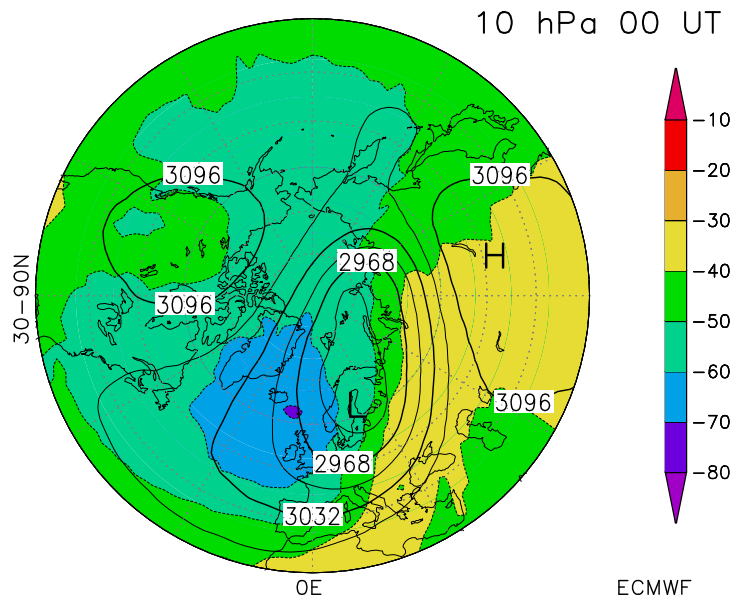


start time and altitude

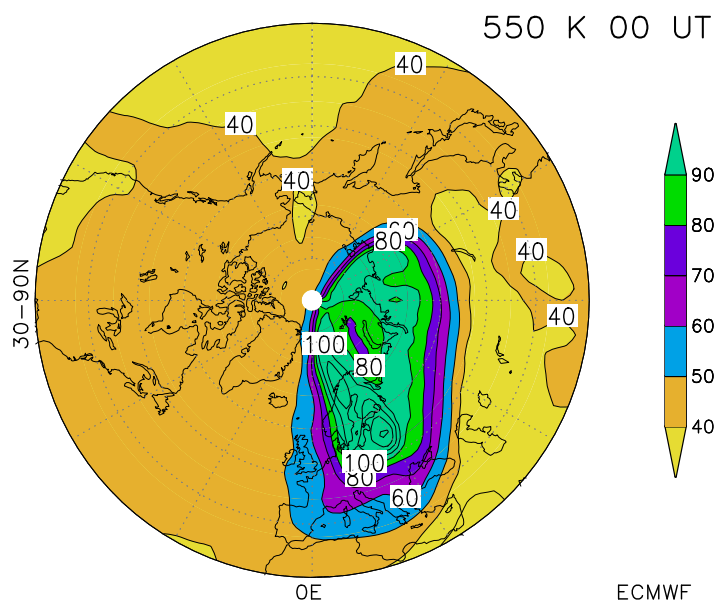
△	06.03.03 08:10 UT	33 km	×	06.03.03 10:00 UT	15 km
+	06.03.03 08:00 UT	33 km	◇	06.03.03 09:50 UT	17 km
×	06.03.03 07:50 UT	32 km	△	06.03.03 09:40 UT	19 km
◇	06.03.03 07:40 UT	29 km	+	06.03.03 09:30 UT	22 km
△	06.03.03 07:30 UT	25 km	×	06.03.03 09:20 UT	24 km
+	06.03.03 07:20 UT	22 km	◇	06.03.03 09:10 UT	26 km
□	06.03.03 07:10 UT	19 km	△	06.03.03 09:00 UT	28 km
×	06.03.03 07:00 UT	16 km	+	06.03.03 08:50 UT	29 km
◇	06.03.03 06:50 UT	13 km	□	06.03.03 08:40 UT	31 km
△	06.03.03 06:40 UT	11 km	×	06.03.03 08:30 UT	32 km
+	06.03.03 06:30 UT	9 km	◇	06.03.03 08:20 UT	32 km

# MIPAS Flight, 20./21.03.03, Kiruna

Geopotential Height [gdam], Temperature [°C]

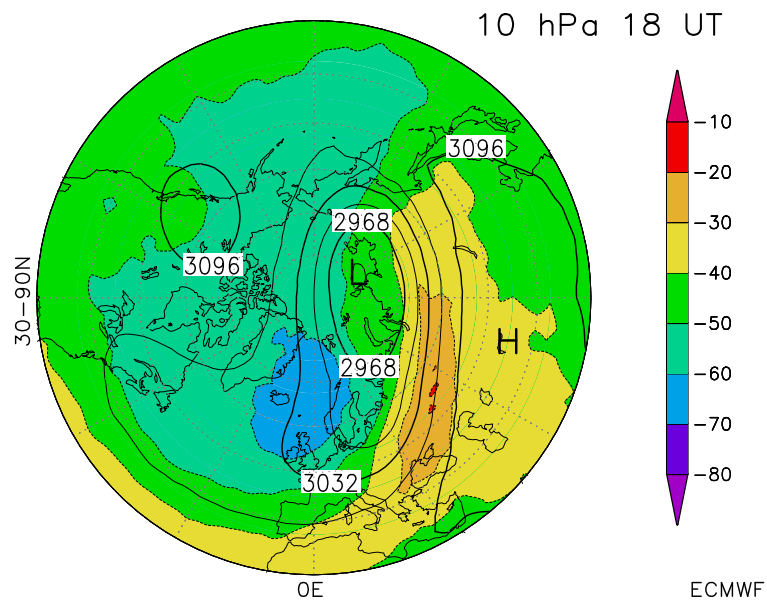


Potential Vorticity [ $10^{-6}$  K m<sup>2</sup>/kg s]

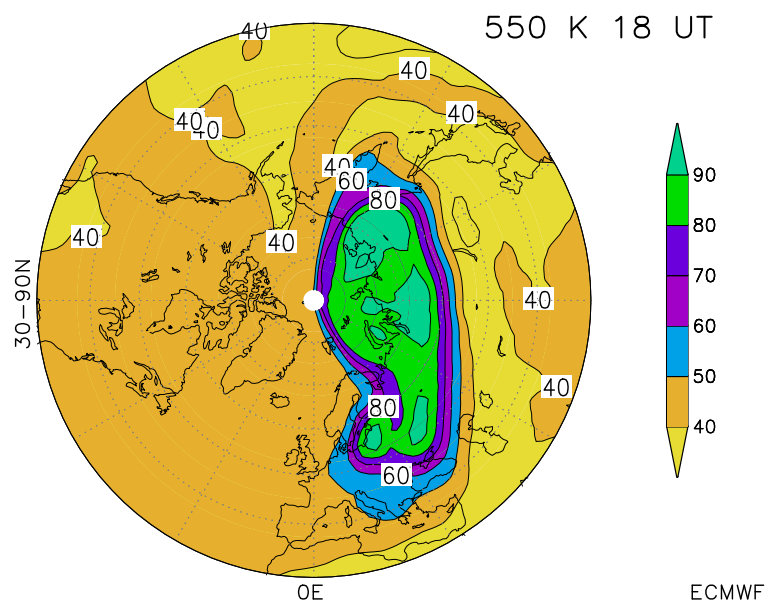


# LPMA/DOAS Flight, 23.03.03, Kiruna

Geopotential Height [gdam], Temperature [ $^{\circ}$ C]



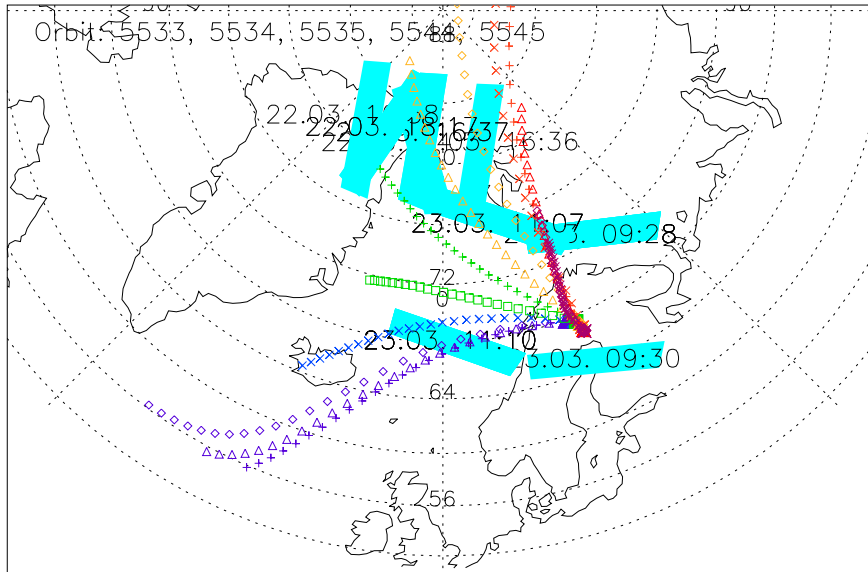
Potential Vorticity [ $10^{-6}$  K m<sup>2</sup>/kg s]



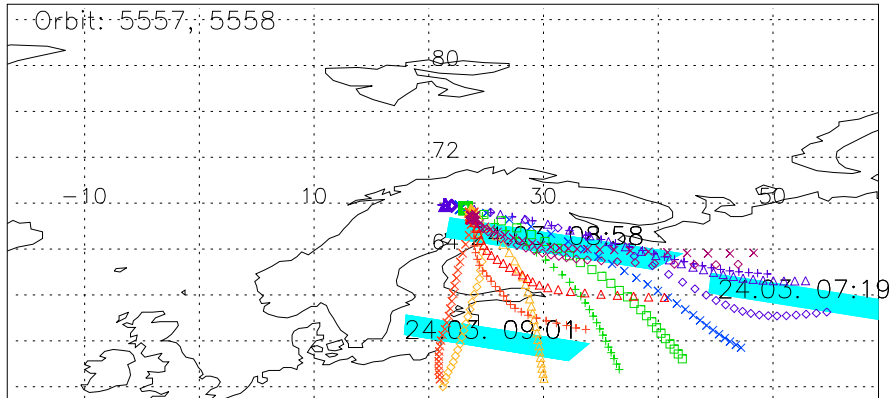
# LPMA/DOAS Flight, 23.03.03, Kiruna

Trajectories started at analysed balloon measurement points and colocated LIMB scans of Sciamachy

1 day backward trajectories - balloon ascent, Scia LIMB



1 day forward trajectories - balloon ascent, Scia LIMB



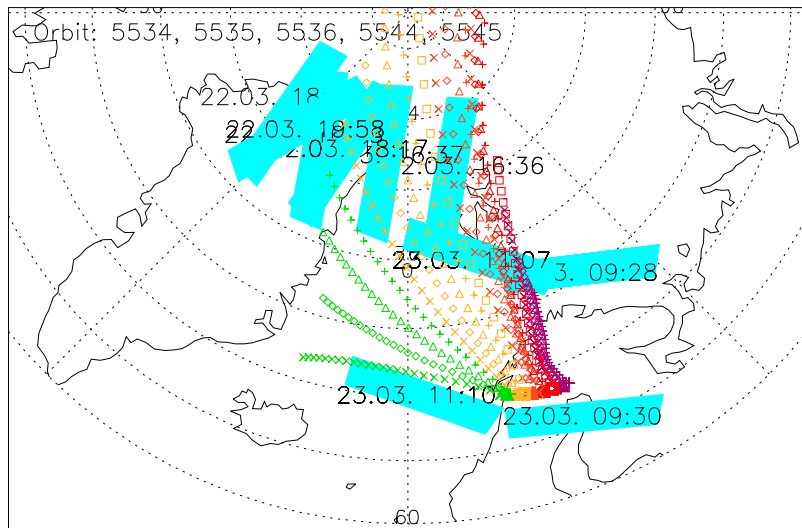
start time and altitude

△	23.03.03 15:50 UT	20.5 km	×	23.03.03 16:40 UT	31.8 km
+	23.03.03 15:40 UT	18.0 km	◇	23.03.03 16:40 UT	31.3 km
□	23.03.03 15:30 UT	15.8 km	△	23.03.03 16:30 UT	30.1 km
×	23.03.03 15:20 UT	13.7 km	+	23.03.03 16:20 UT	28.7 km
◇	23.03.03 15:00 UT	9.5 km	×	23.03.03 16:10 UT	26.3 km
△	23.03.03 14:50 UT	7.1 km	◇	23.03.03 16:00 UT	23.4 km
+	23.03.03 14:50 UT	6.0 km			

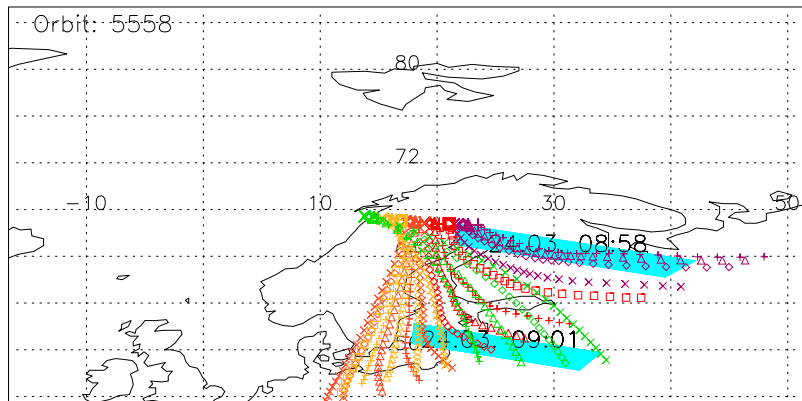
# LPMA/DOAS Flight, 23.03.03, Kiruna

Trajectories started at analysed balloon measurement points and colocated LIMB scans of Sciamachy

1 day backward trajectories - sunset, Scia LIMB



1 day forward trajectories - sunset, Scia LIMB



start time and altitude

△	23.03.03 17:00 UT	27.0 km	×	23.03.03 17:20 UT	16.6 km
+	23.03.03 17:00 UT	27.7 km	◇	23.03.03 17:20 UT	17.6 km
×	23.03.03 17:00 UT	28.3 km	△	23.03.03 17:20 UT	18.8 km
◇	23.03.03 17:00 UT	29.0 km	+	23.03.03 17:20 UT	19.8 km
△	23.03.03 17:00 UT	29.5 km	×	23.03.03 17:20 UT	20.8 km
+	23.03.03 17:00 UT	30.0 km	◇	23.03.03 17:10 UT	21.8 km
□	23.03.03 16:50 UT	30.8 km	△	23.03.03 17:10 UT	22.7 km
×	23.03.03 16:50 UT	31.3 km	+	23.03.03 17:10 UT	23.7 km
◇	23.03.03 16:50 UT	31.7 km	□	23.03.03 17:10 UT	24.6 km
△	23.03.03 16:50 UT	32.0 km	×	23.03.03 17:10 UT	25.4 km
+	23.03.03 16:40 UT	31.9 km	◇	23.03.03 17:10 UT	26.2 km