ISSI-Project Group of Peter Hoffmann

# Bridging the gap between the middle and upper atmosphere: Coupling processes due to winds and waves over an extended altitude range

Noctilucent cloud in the mesosphere (photo by B. Whittaker)

**...what happens beyond?**

## Focus of the project:
## Atmosphere dynamics from 60 to 120km altitude

**1) Wave-mean flow interactions**

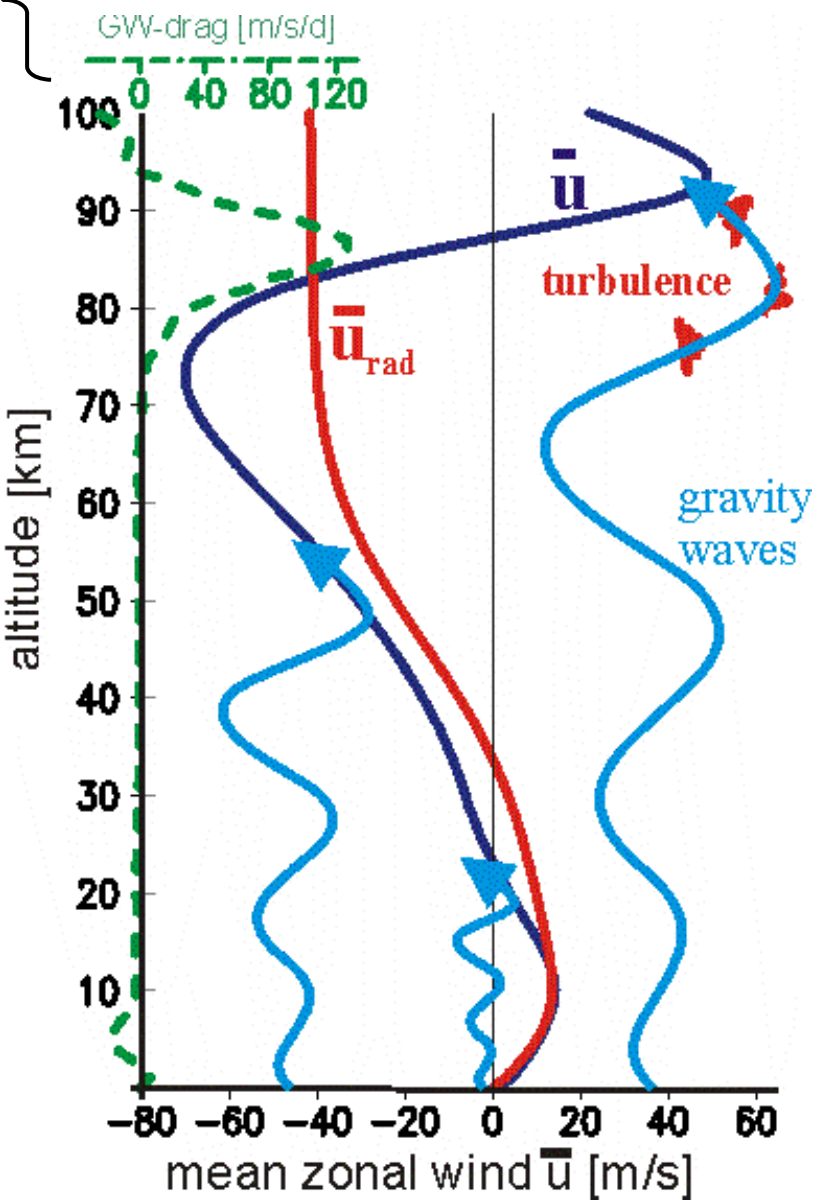
•Forcing of mean winds by atmospheric waves

•Wind filtering of upward energy and momentum flux of waves

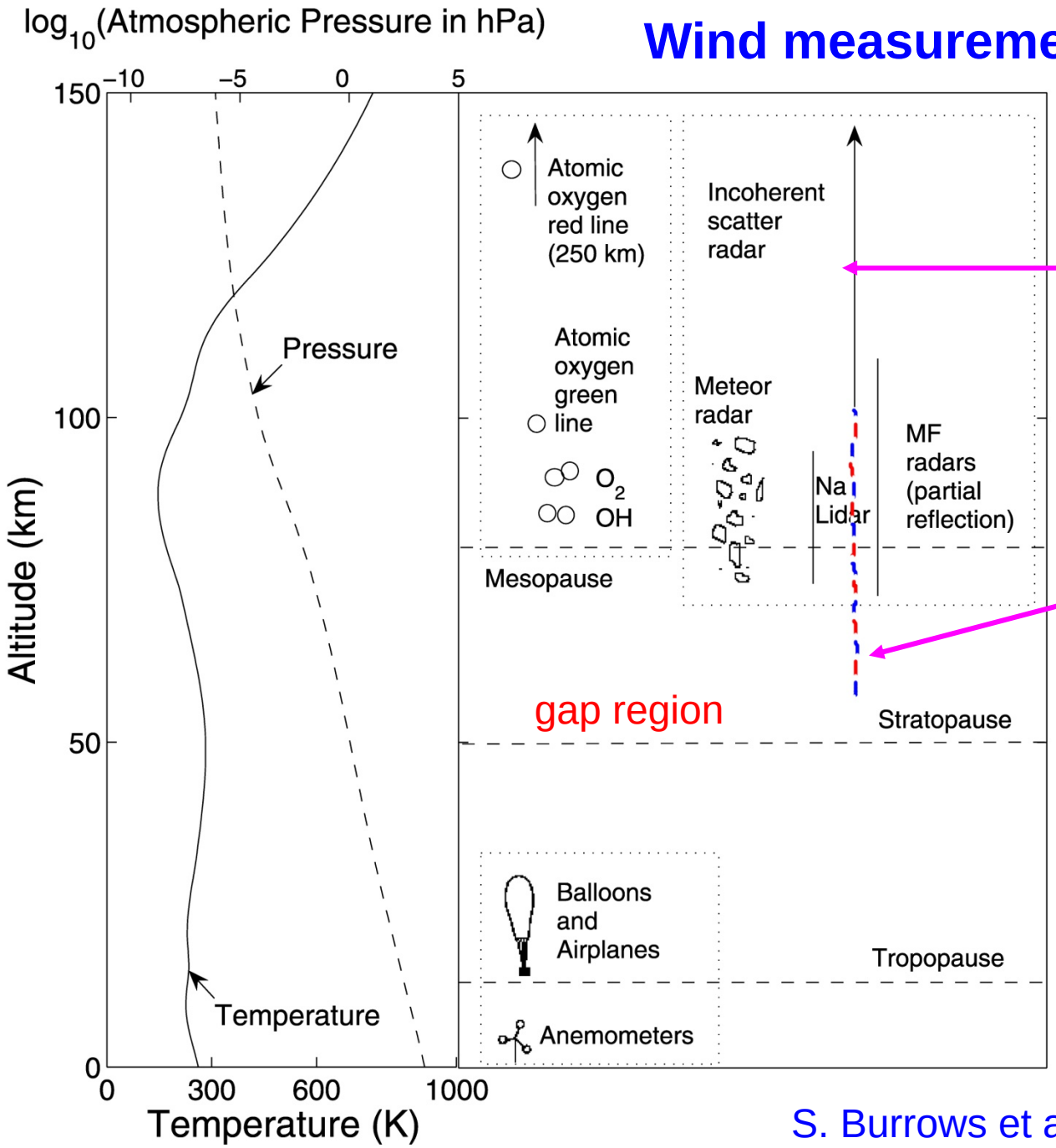
**2) Wave-wave interactions**

**3) Relation between dynamics and atmosphere composition**

(including ionospheric plasma)



# Wind measurement techniques:




Beyond 120 km
maybe not

only, if enough
electron density
is present

microwave
radiometry
has potential

PS:
rockets cover
the whole range

S. Burrows et al. (2007)

# Our Approach:

- **Combine wind measurements from radar networks:**
  Incoherent Scatter Radars (ISR), MF radars, meteor radars

- **Establish a long-term wind database covering the altitude range 60-120 km**
  (important progress: derivation of neutral wind profile from ion velocity measurement of ISR )

- **Intercomparisons between Ground Stations, Satellites (TIMED/SABER), and Whole Atmosphere Model (HAMMONIA)**

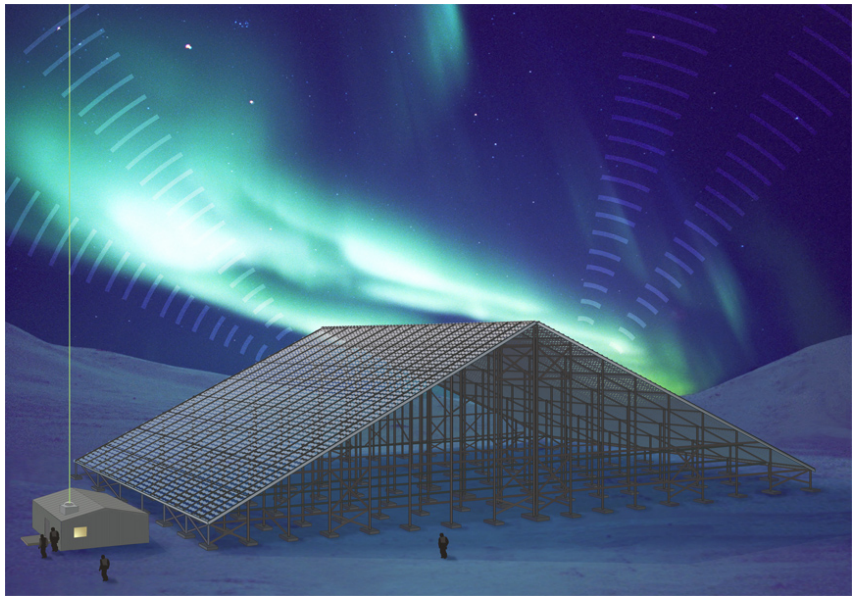
- **Model interpretation of observed dynamics and composition changes**

## Our ISSI-team:

| | |
|---|---|
| **IAP Kühlungsborn** | P. Hoffmann (Coord.), N. Grieger<br>(Radar observation, Modell) |
| **EISCAT:** | I. Häggström, M. Rietveld, T. v. Eyken<br>S. Nozawa (University of Nagoya),<br>R. Behlke (Univ. of Longyearbyen)<br>C. Hall (Univ. of Tromso) |
| **Stanford Research International:** | C. Heinselman, M. Nicolls<br>(Poker Flat ISR, ISR Sondreström,<br>New AMISR _ Advanced modular ISR) |
| **University of Bern:** | K. Hocke, A. Haefele, T. Flury -<br>Microwave observations in the upper stratosphere |
| **MIT Haystack Observatory**: | L. Goncharenko (ISR Millstone Hill Sondreström) |
| **University of Bath**: | D. Sandford, V. Tunbridge (N. Mitchell) – Meteor radars |
| **MPI Hamburg:** | H. Schmidt – HAMMONIA model |
| **University of Wuppertal:** | J. Oberheide (Satellite - TIDI, model) |

→ very good expertise (ground based experiments, Satellites, Models) to work on these points !

# Incoherent scatter radars:

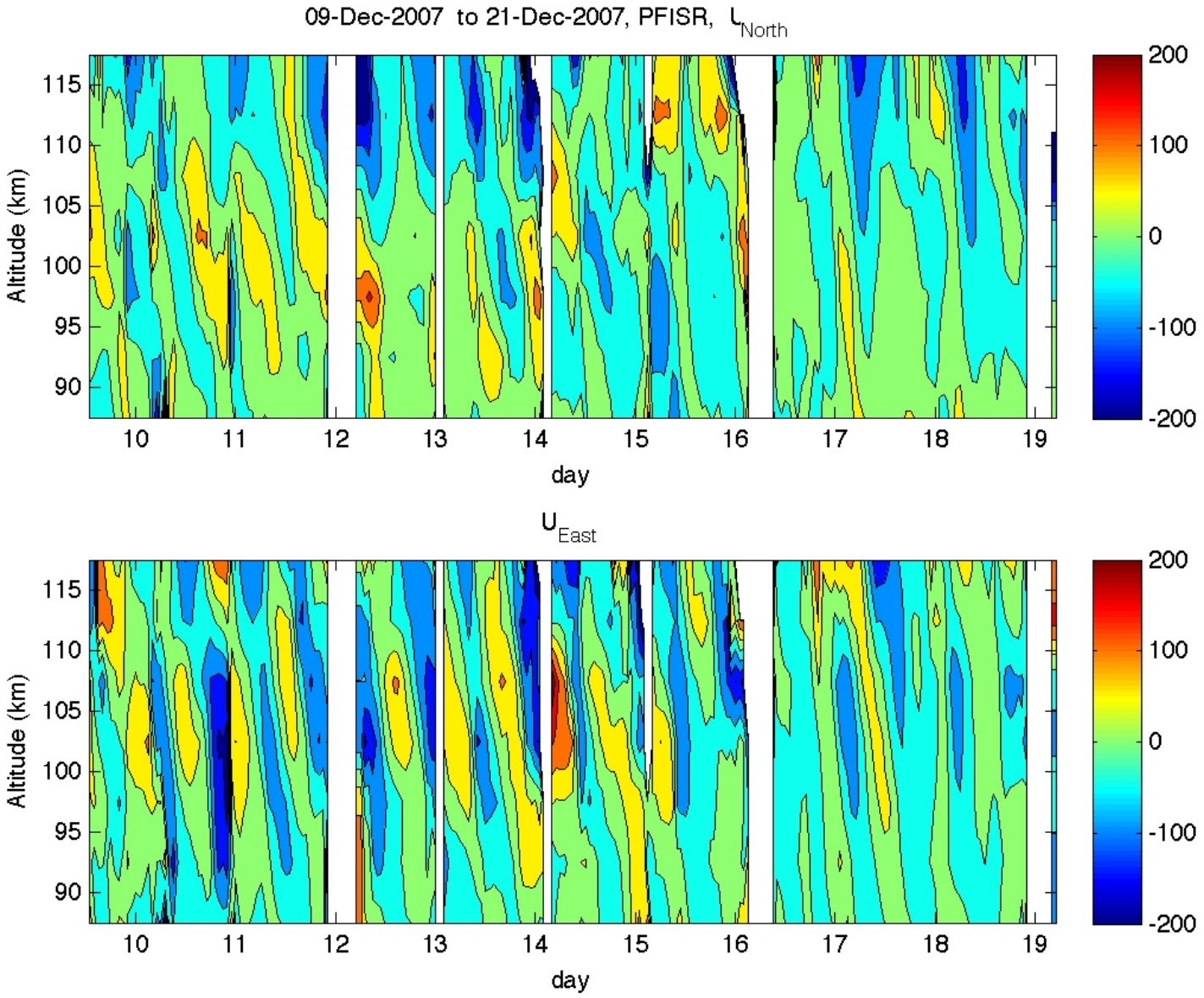


Advanced Modular ISR (AMISR) under construction, Resolute Bay, Canada, SRI

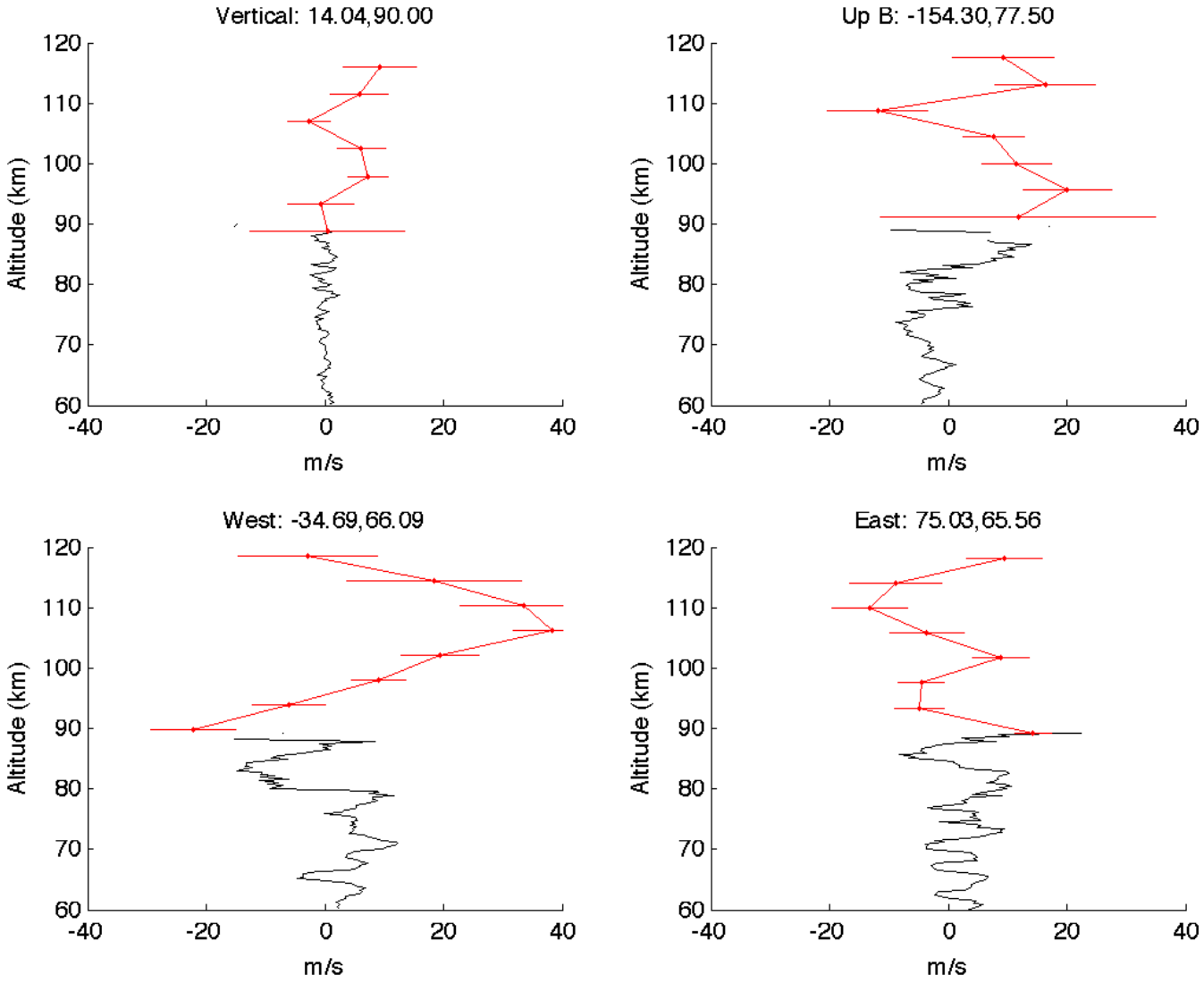
Poker Flat ISR in Alaska, SRI

EISCAT (Europe)

# Horizontal winds by Poker Flat Incoherent Scatter Radar (C. Heinselmann, M. Nicolls)



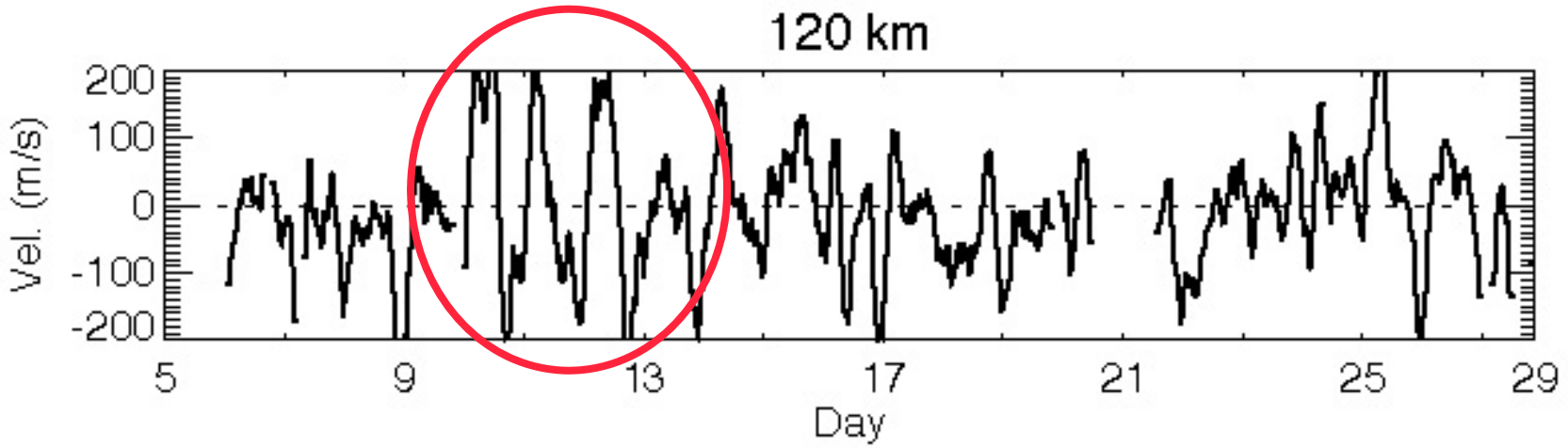
# 4-D Atmospheric Wave Observation by Beam Steering of Poker Flat ISR:



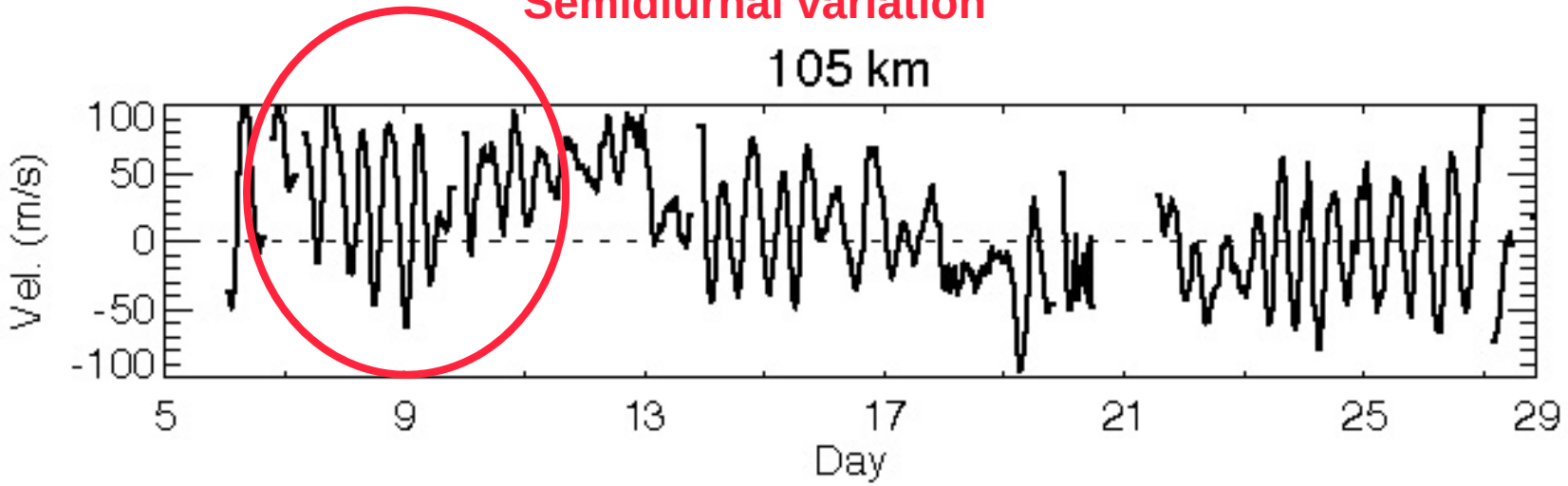
# EISCAT: Temporal variation of the neutral wind at Tromsø from September 6 to 29, 2005 (S. Nozawa)

Zonal component

Diurnal variation

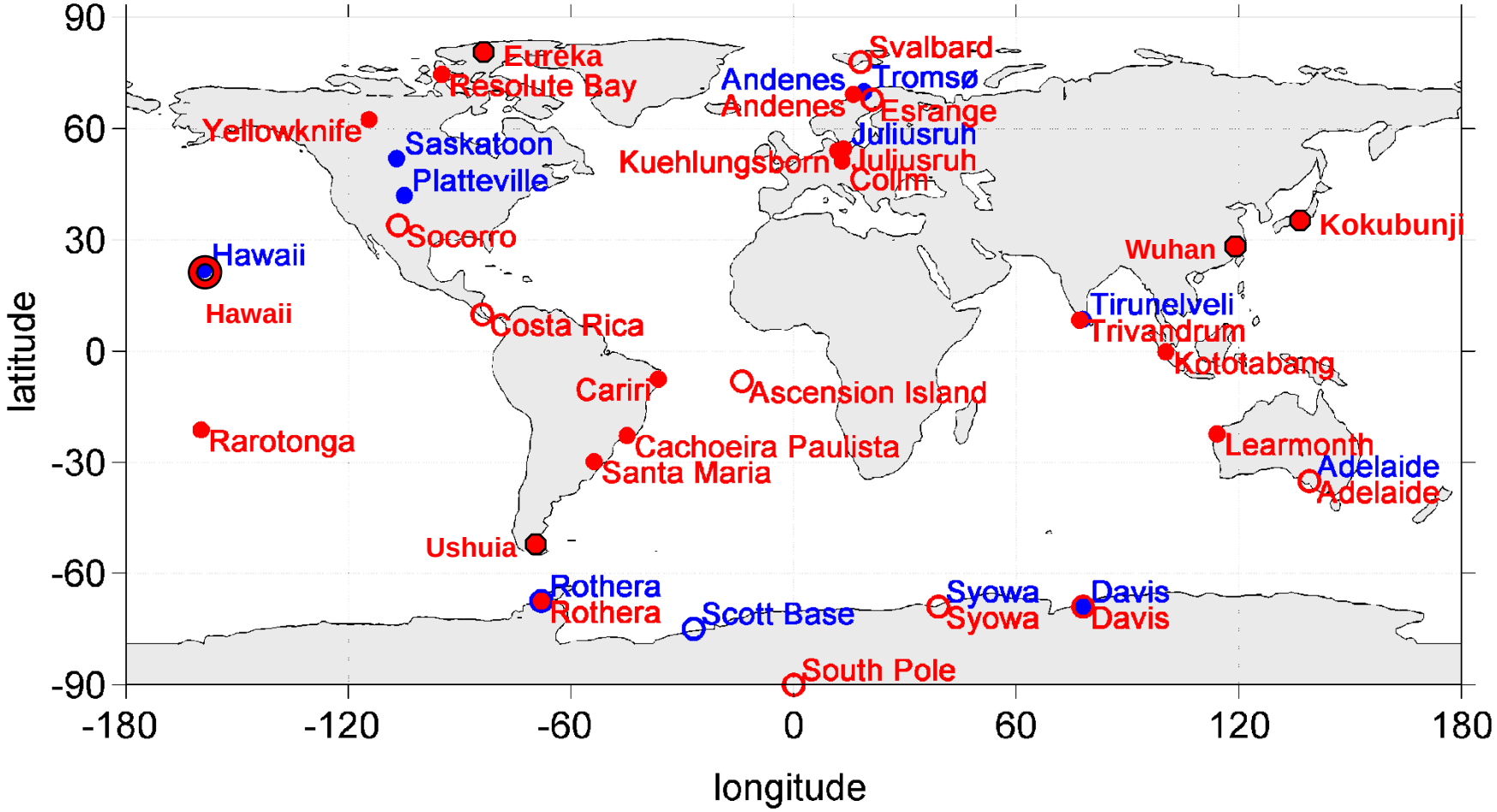



**Semidiurnal variation**



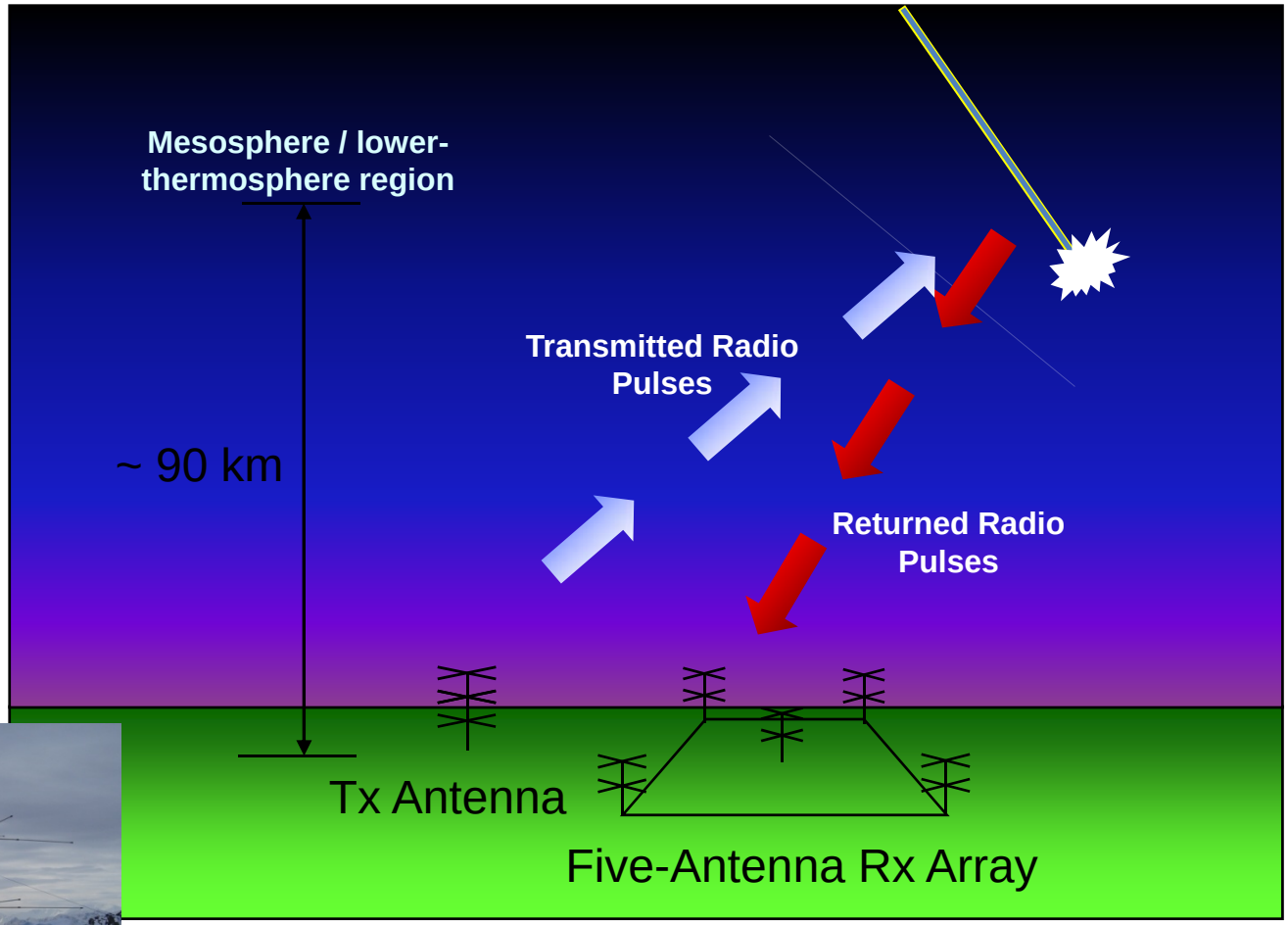

30 min average

# Wind Measurements by MF Radars and Meteor Radars




from W. Singer

# Meteor and MF Radar Technique:
# Reflections from meteor trail and plasma irregularities
# (drift ⟶ horizontal neutral wind)

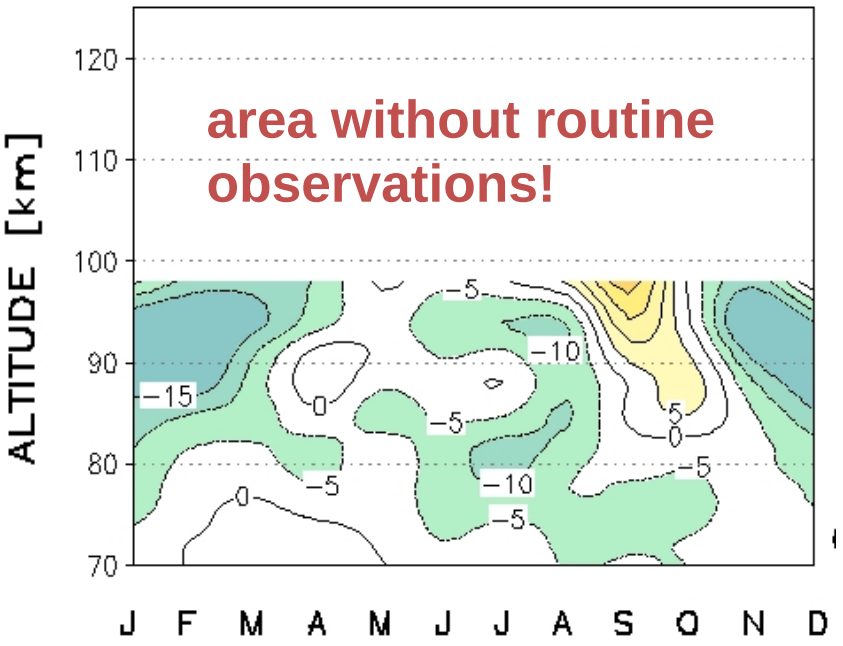


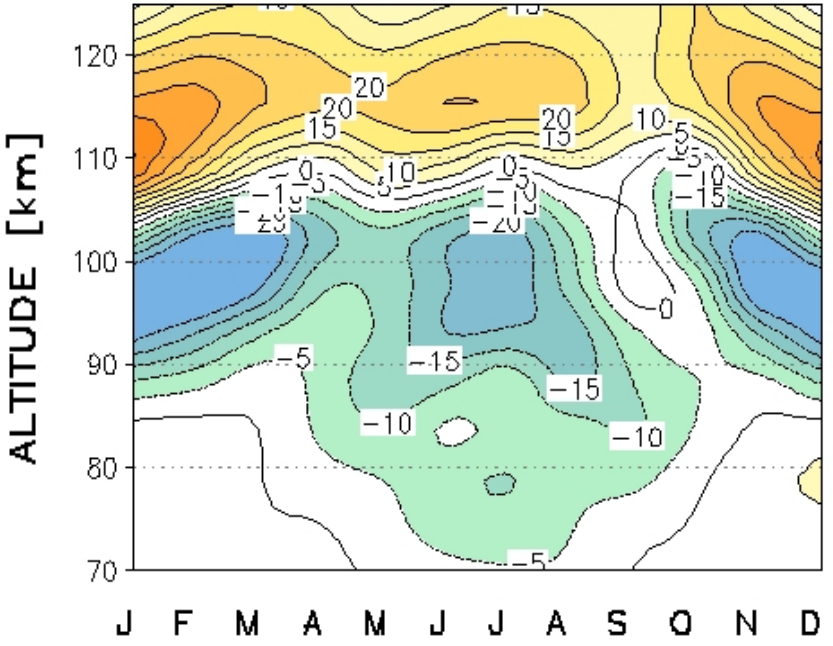

Meteor radar on Antarctic Peninsula (D. Sandford, University of Bath)

# Seasonal Change of Meridional Wind over Andenes (69 N) in 2005:

**Observation**
Meteor and MF radar
Norbert Grieger

**Model**
HAMMONIA
Hauke Schmidt



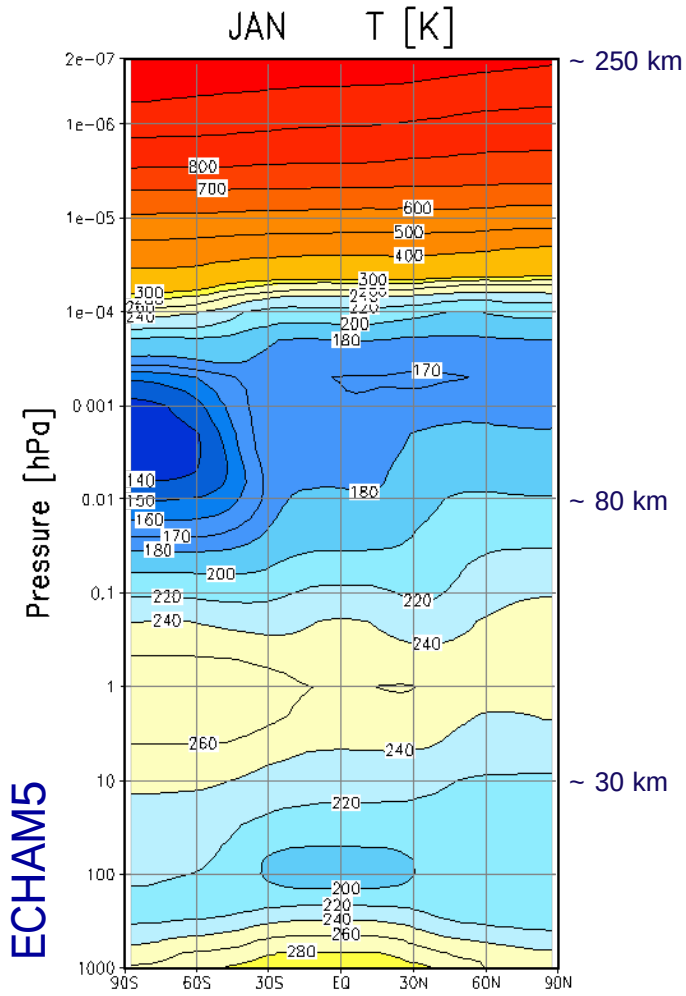

**Aim of our group:** Improve observations and modeling of neutral winds

# HAMMONIA – a member of the ECHAM family (Hauke Schmidt)

HAMMONIA

MAECHAM5

ECHAM5




~ 250 km

~ 80 km

~ 30 km

Solar Heating (near UV, vis. & near IR)

Solar Heating (SRB&C, Ly-a, EUV)

IR Cooling (non-LTE)

IR Cooling

Chemical heating

Surface Fluxes

Clouds & Convection

Turbulent Diffusion

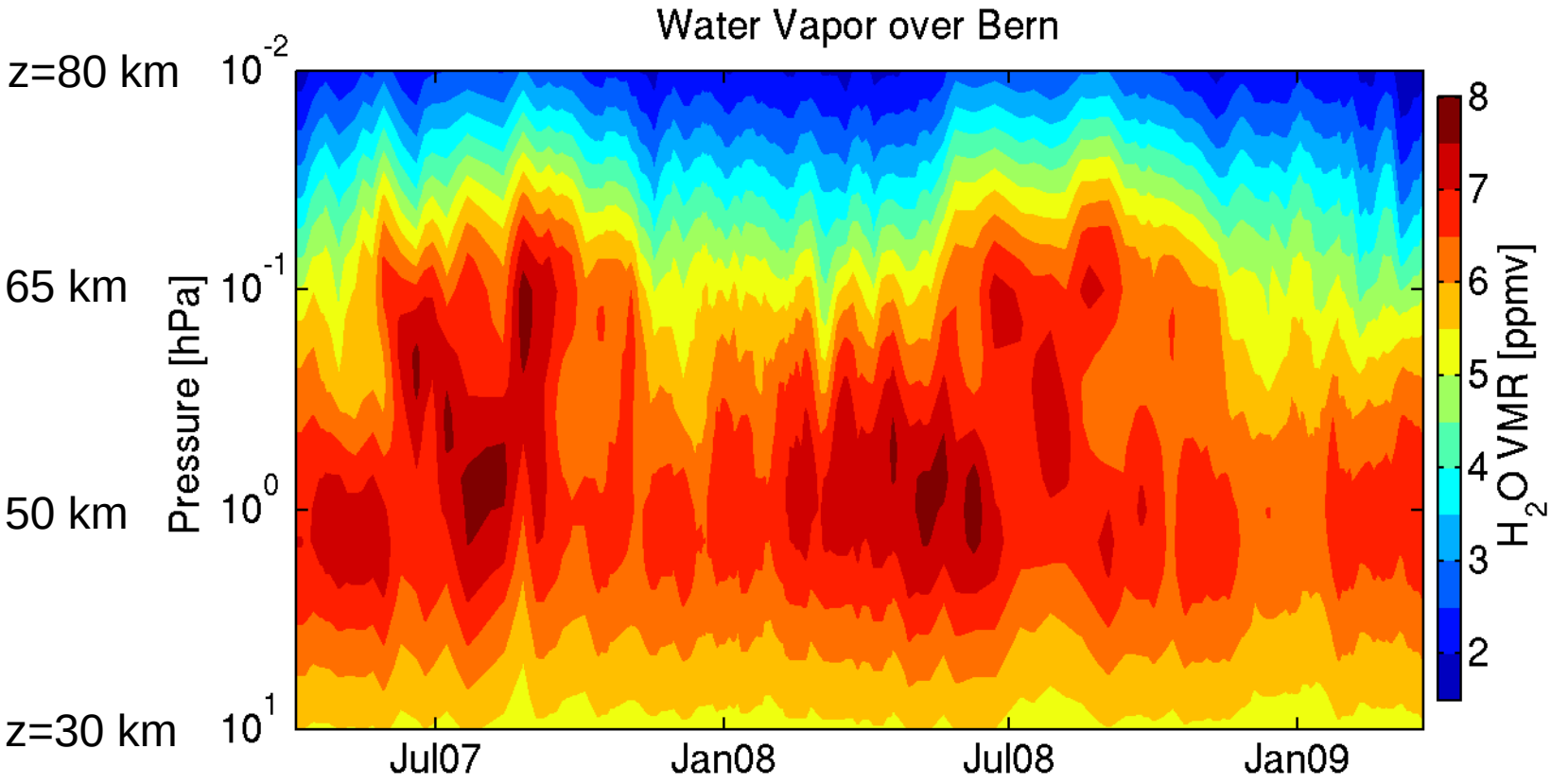
Gravity Wave Drag

Molecular Processes

Ion Drag

Neutral (and Ion) Chemistry (MOZART3)

# Ozone and Water Vapour: Tracing and Forcing the Dynamics




from A. Haefele

Ground-based microwave radiometers at Bern continuously monitor the water vapour and ozone distribution

## Concrete work tasks of our group:

- Validation of wind measurements

- Reprocessing of wind data from old measurements (z=60-120 km, ISR)

- Construction of a wind database

## Concrete research tasks:

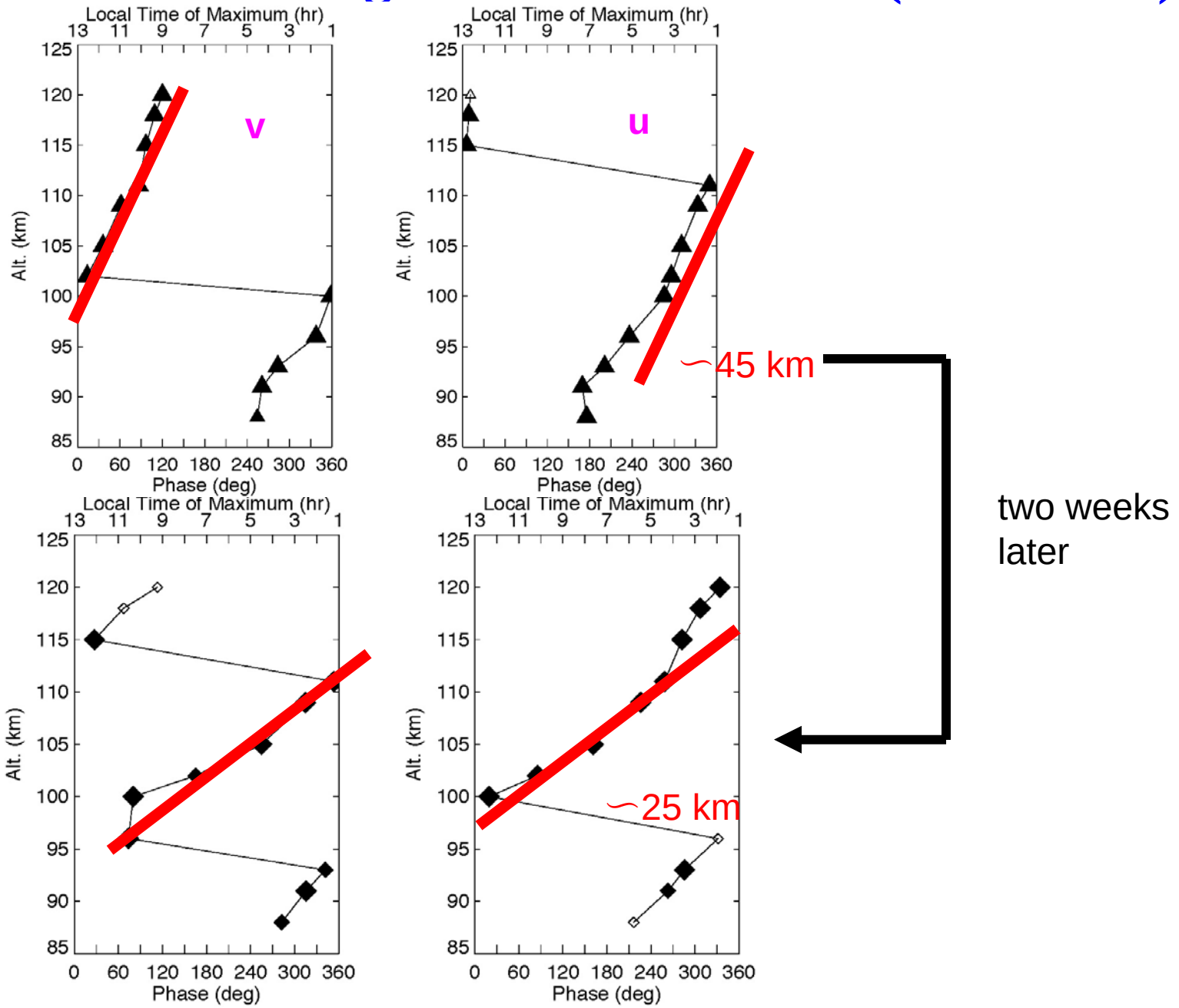
1) Tidal waves in observations and models

2) Sudden stratospheric warming (SSW) as a whole atmosphere disturbance

3) Vertical coupling by gravity waves

4) Dependences on longitude, latitude, altitude, time

# 1) Wave mode switching of semidiurnal tide (S. Nozawa):



# 2) Radar observations of winds, Gravity waves and turbulence at Andenes (ALOMAR)

**a) zonal winds at Andenes (Meteor-Radar 82 - 94 km, MF-Radar 70 - 82 km);**

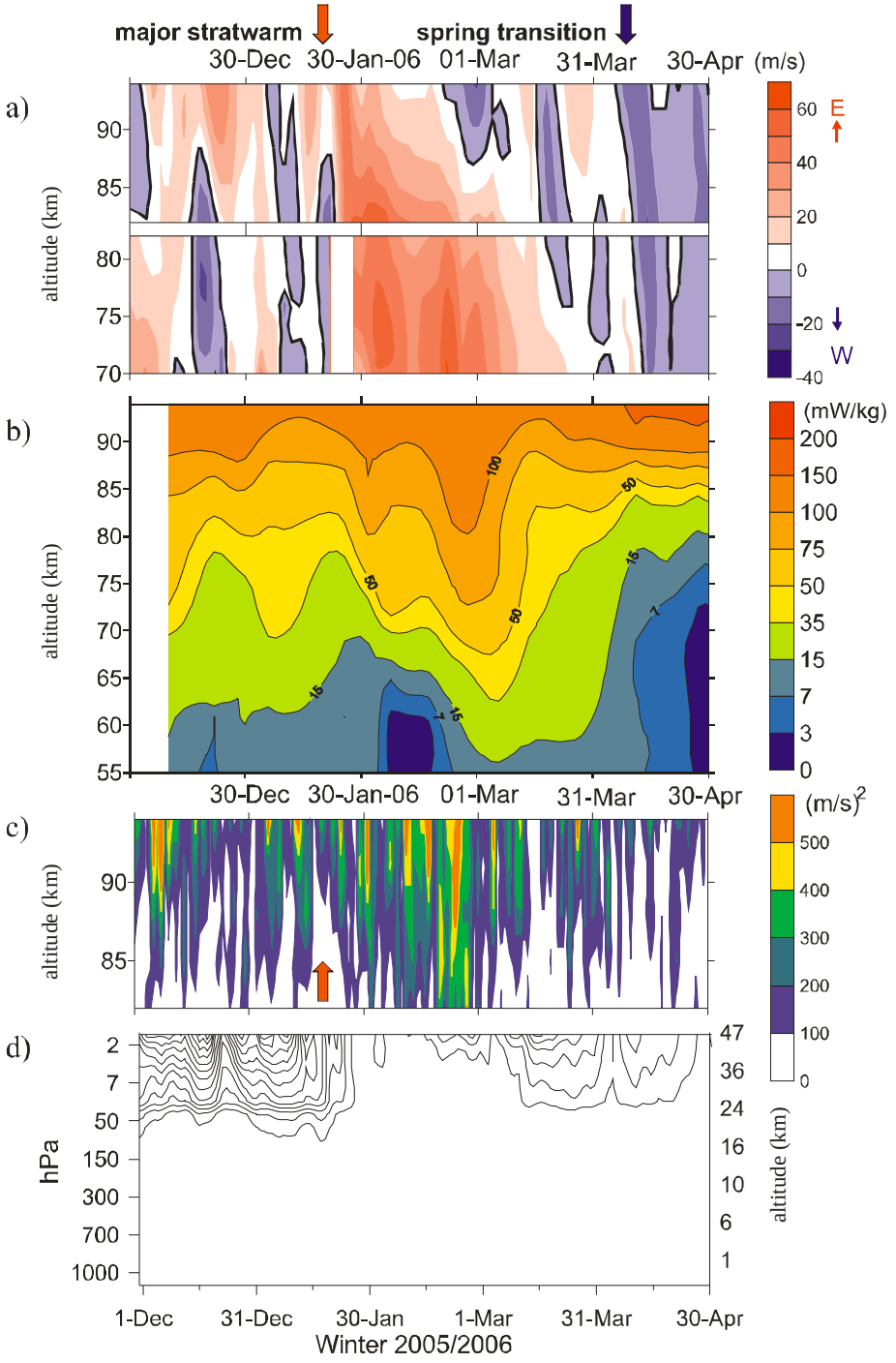
**b) turbulent energy dissipation rate (Saura MF-Radar);**

**c) gravity wave activity (periods 3 - 9 h) (Meteor-Radar)**

**d) ECMWF-data: (M. Kunze, FU Berlin) amplitude of wave 1 in 60°N (1. contour: 500 m; steps of 200 m)**

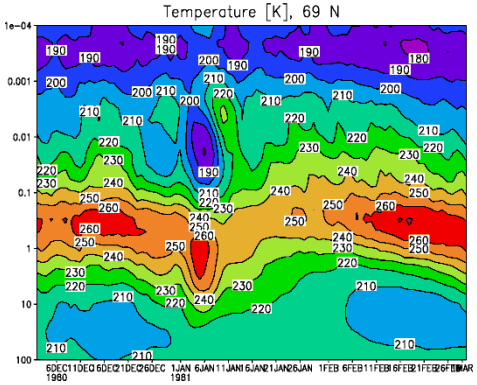
**during ssw → reduced gravity wave activity and energy dissipation rate in the MLT region → consistent with the mesospheric cooling**

**after that → weak pw → gravity waves can propagate up the mesopause where they dissipate**



**Sudden Stratospheric Warming is an ideal theme for interdisciplinary work:**

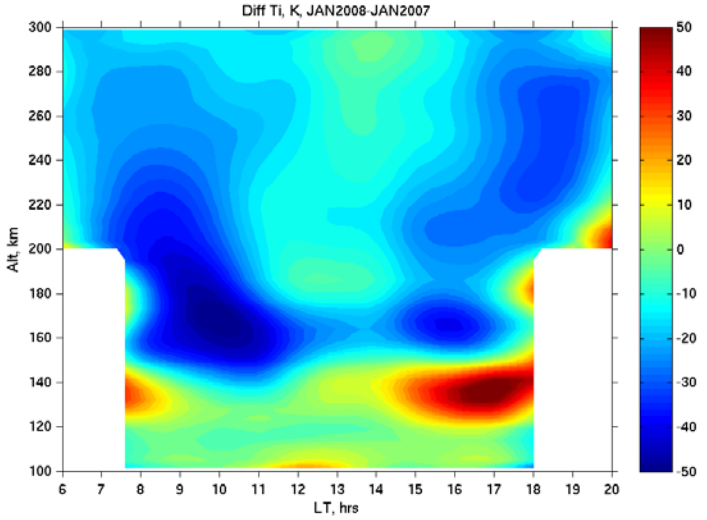
- effect of SSW on atmospheric chemistry
- effect of SSW on the ionosphere
- effect of SSW on dynamics and energetics
- effect of SSW on the troposphere
- ...




**SSW in HAMMONIA**

**We want to understand and quantify:**

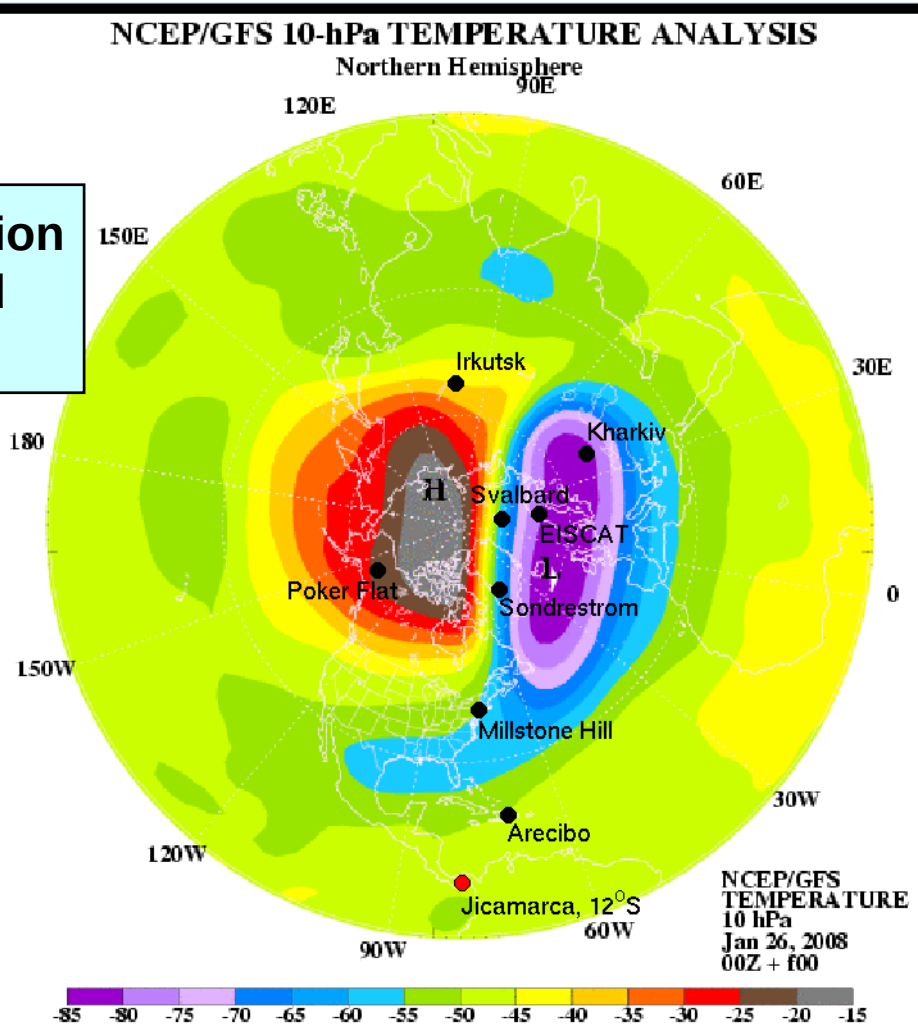
- the reasons of SSWs
- the 4-D evolution
- transport processes and composition changes
- ...




**SSW effect in ion temperature (Millstone Hill ISR, L. Goncharenko)**

# Locations of ISR radars and wave 1 in temperature at 10 hPa before SSW (L. Goncharenko)

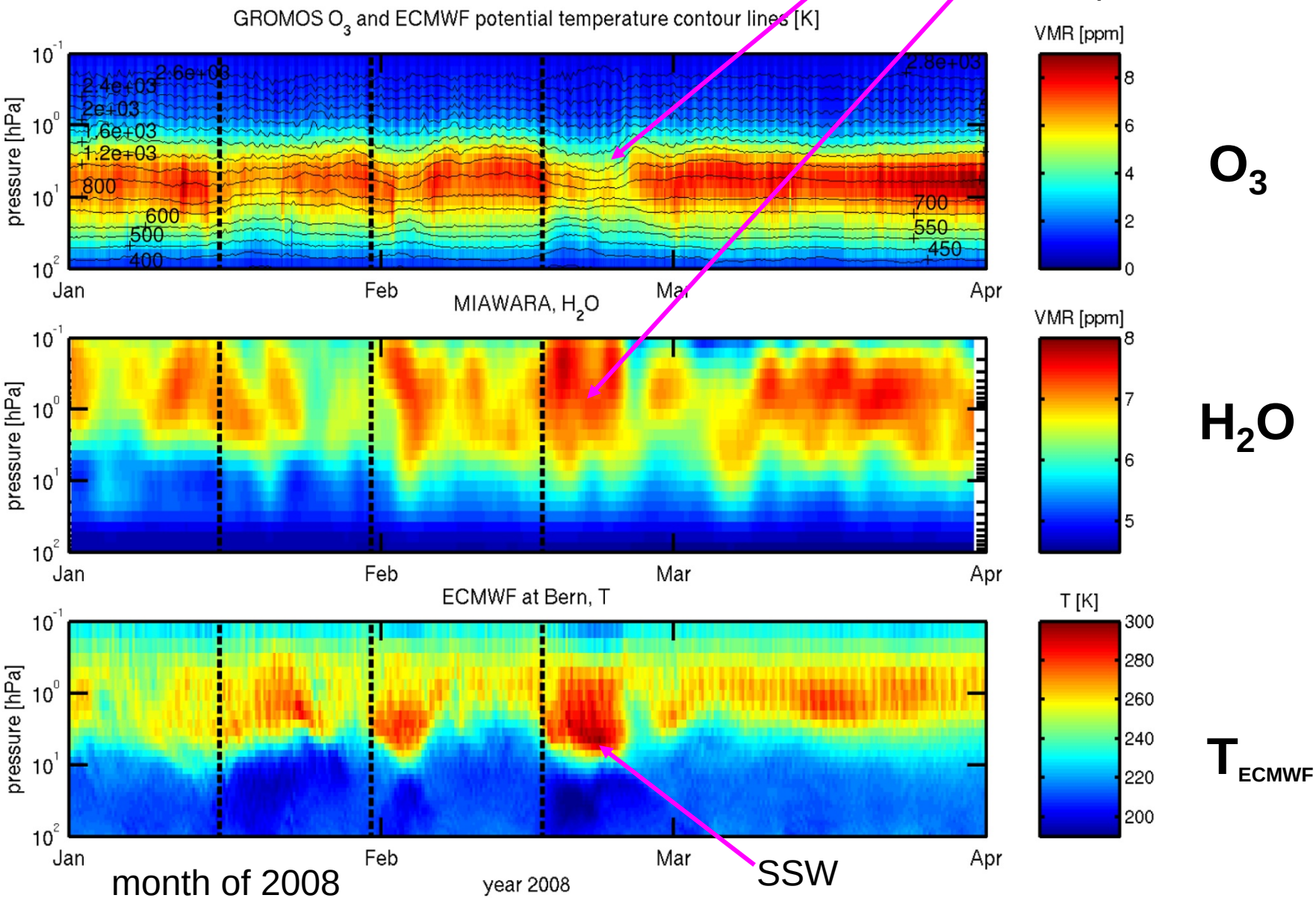
**Ideal configuration for IPY, SPE and SSW studies!**




**February 2008 and January 2009 had major SSWs (polar vortex shift and polar vortex splitting respectively)**

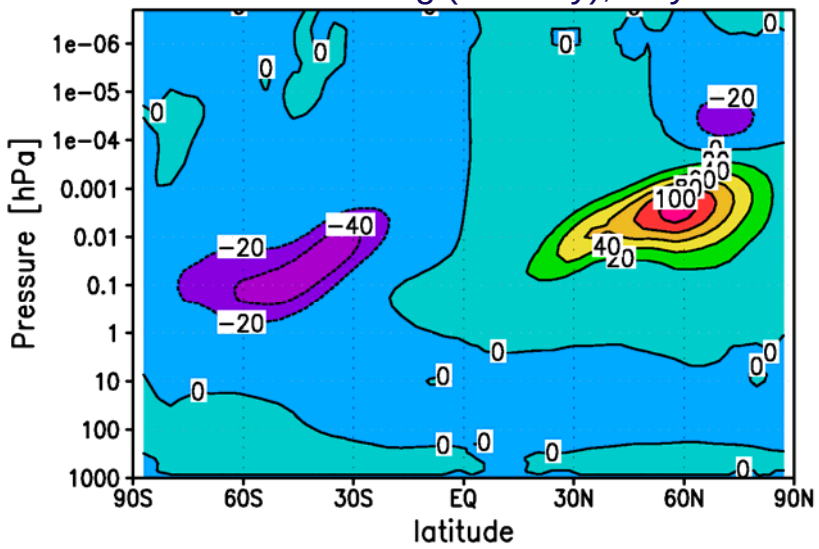
# SSW of February 2008 over Bern:

**(ground-based microwave radiometer)**

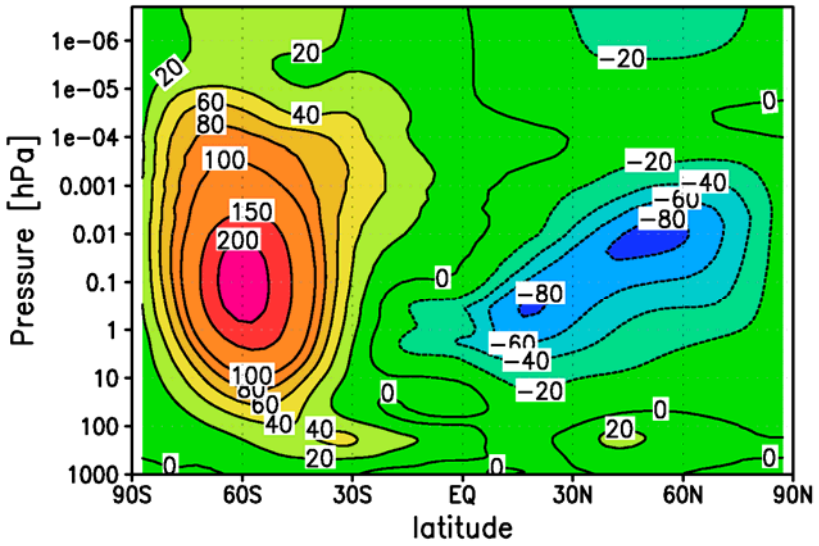


# 3) HAMMONIA: Dramatic effect of gravity wave drag on zonal wind

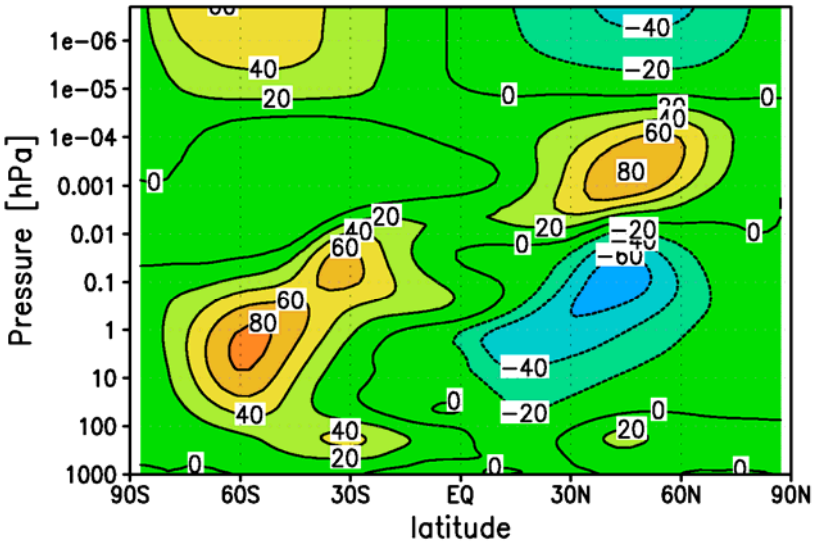
zonal GW drag (m/s/day), July




u (m/s), no GW drag, July




u (m/s), July



# Cooperation with other campaigns and projects:

+ SCOSTEP programme “Climate and Weather of the Sun-Earth System” (CAWSES), in particular with the “Global Tidal Project” , initiated by W. Ward, Univ. of New Brunswick, Canada.

+ ISSI Team (ID 133) "Towards More Effective Physics-Based and Statistical Models of the Polar Ionosphere", lead by A. van Eyken.

+ IPY-International Polar Year as large scientific programme focused on the Arctic and the Antarctic from March 2007 to March 2009.

+ German Priority Program SPP 1176 of the DFG (coord. by F.-J.Lübken)
http://www.iap-kborn.de/cawses/

## Thank you for your attention!

Milestones

1) Workshop at ISSI: (October 2008)

Review and determine everyone's contribution to the project;
Review observations and model outputs;
Overview on the derivation of neutral winds from EISCAT measurements;
Define observational modes and campaigns,
Review individual results for selected periods,
Define detailed tasks

2) Workshop at ISSI: (October 2009)
Review detailed tasks
Review first year of observations and model outputs,
detailed discussion on the mesosphere thermosphere response to stratospheric warmings, finalise first papers,

3) Workshop at ISSI:
Comprehensive review article,
several research papers will result from this project. The manuscripts will be finalized at the third and last meeting.
Further model/ observation projects will be discussed and planned.