
Simultaneous and co-located measurements of polar mesosphere winter echoes, electron densities and turbulence

W. Singer, R. Latteck, F.-J. Lübken, M. Zecha

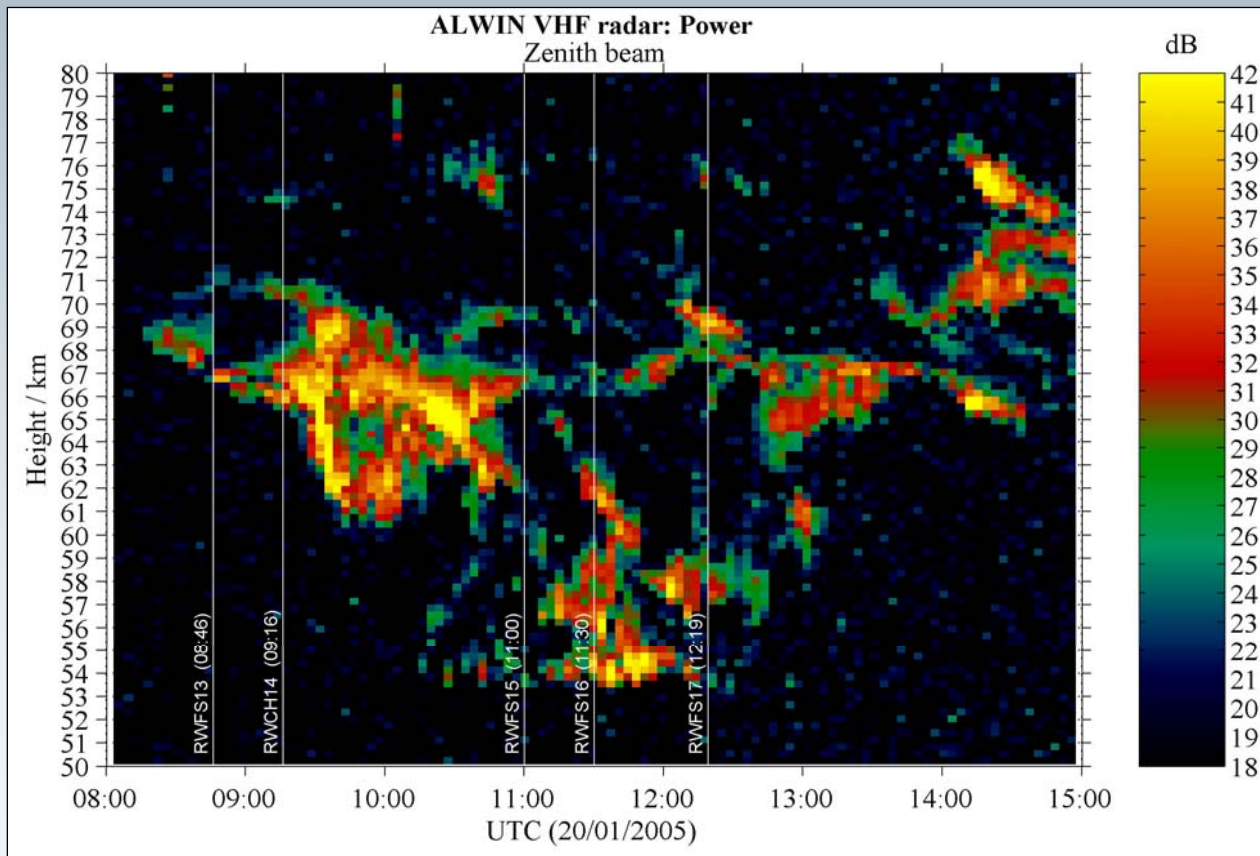
Leibniz-Institute of Atmospheric Physics, 18225 Kühlungsborn,
Germany

Outline

1. Characteristics of PMWE
2. Radar observations & rocket experiments at Andenes
3. PMWE on January 17 - 21, 2005
4. PMWE on December 6 - 15, 2006
5. Summary

Polar Mesosphere Winter Echoes (PMWE)

- strongly enhanced radar echoes from mesospheric heights of about 55 to 75 km
- $\sim 3\%$ occurrence rate compared to $\sim 90\%$ occurrence rate for PMSE @ 69°N

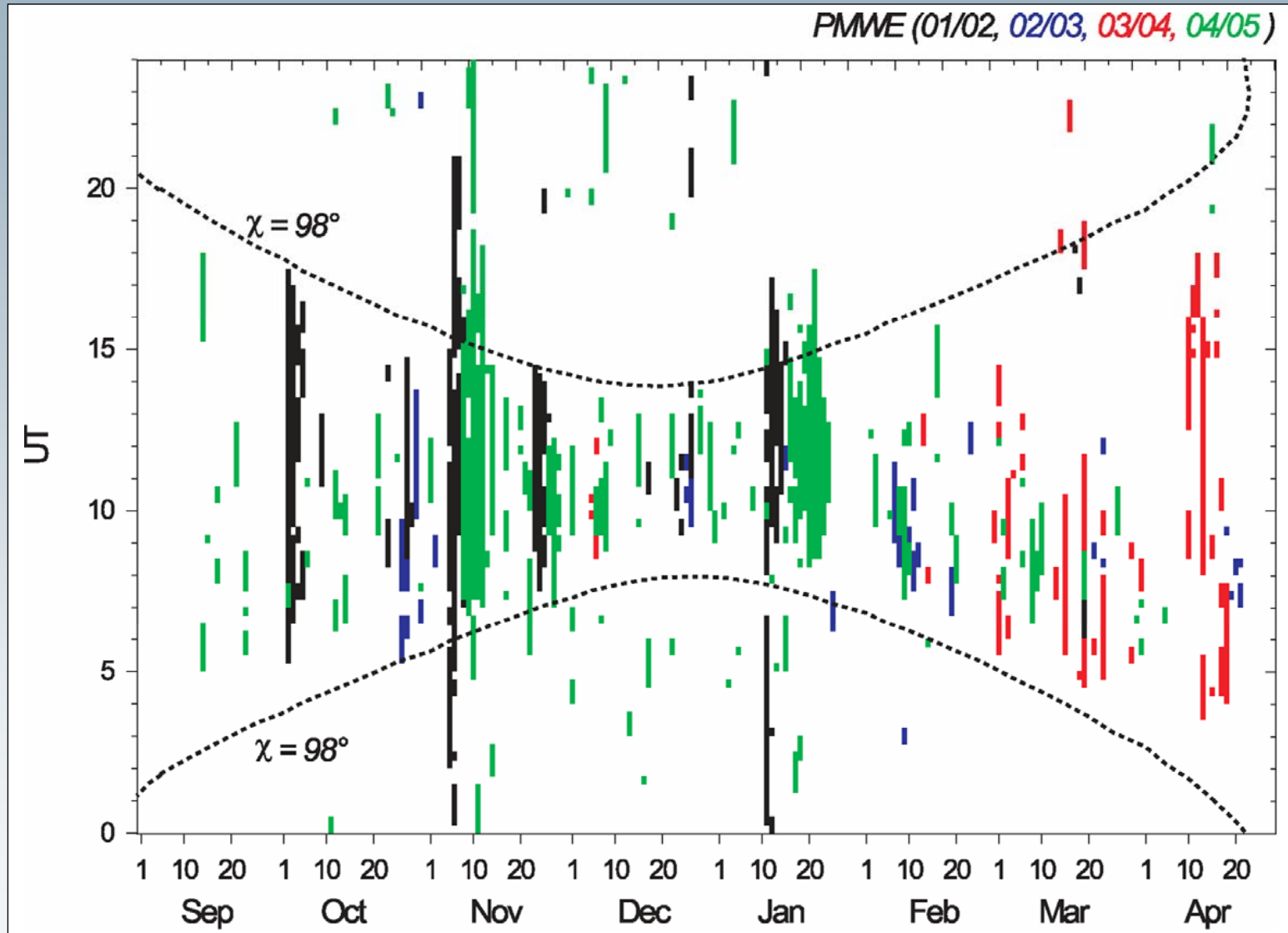


Proposed mechanisms:

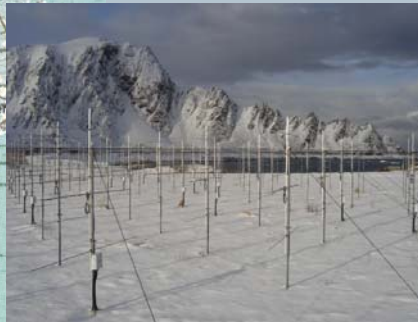
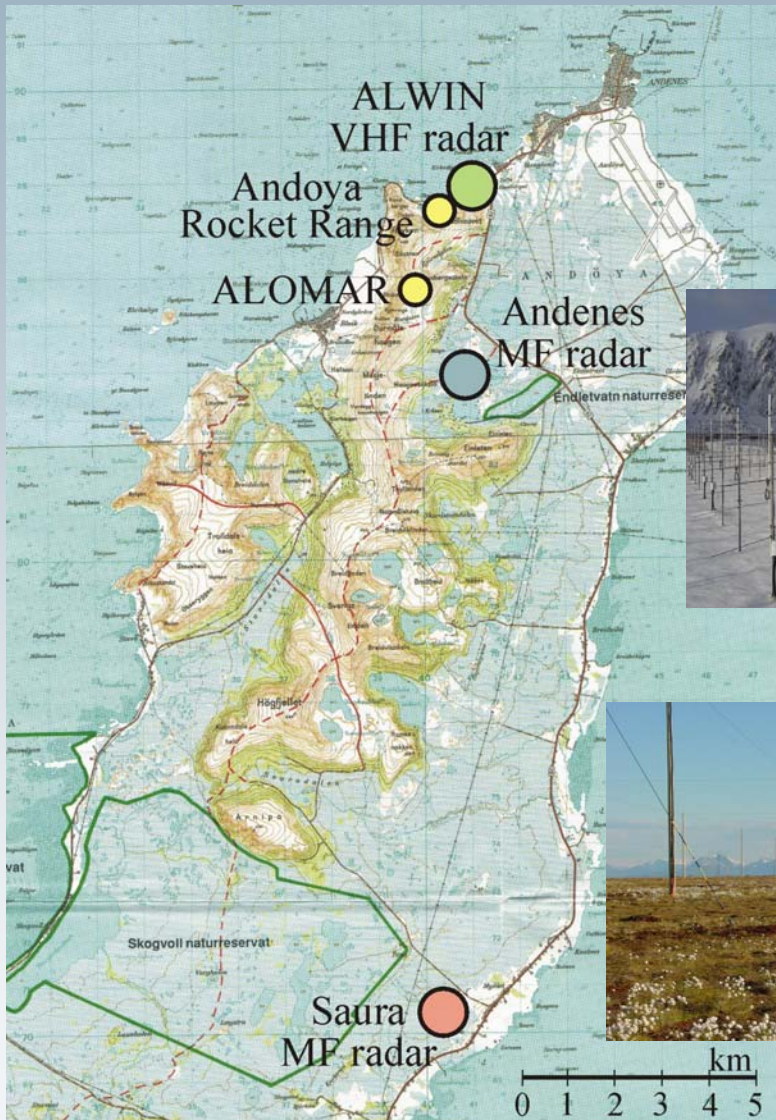
- turbulence
- scatter from evanescent ion-acoustic waves generated by partial reflection of infrasonic waves
- aerosol particles

Characteristics of PMWE

observations at Andenes Sept. 2001 – March 2005

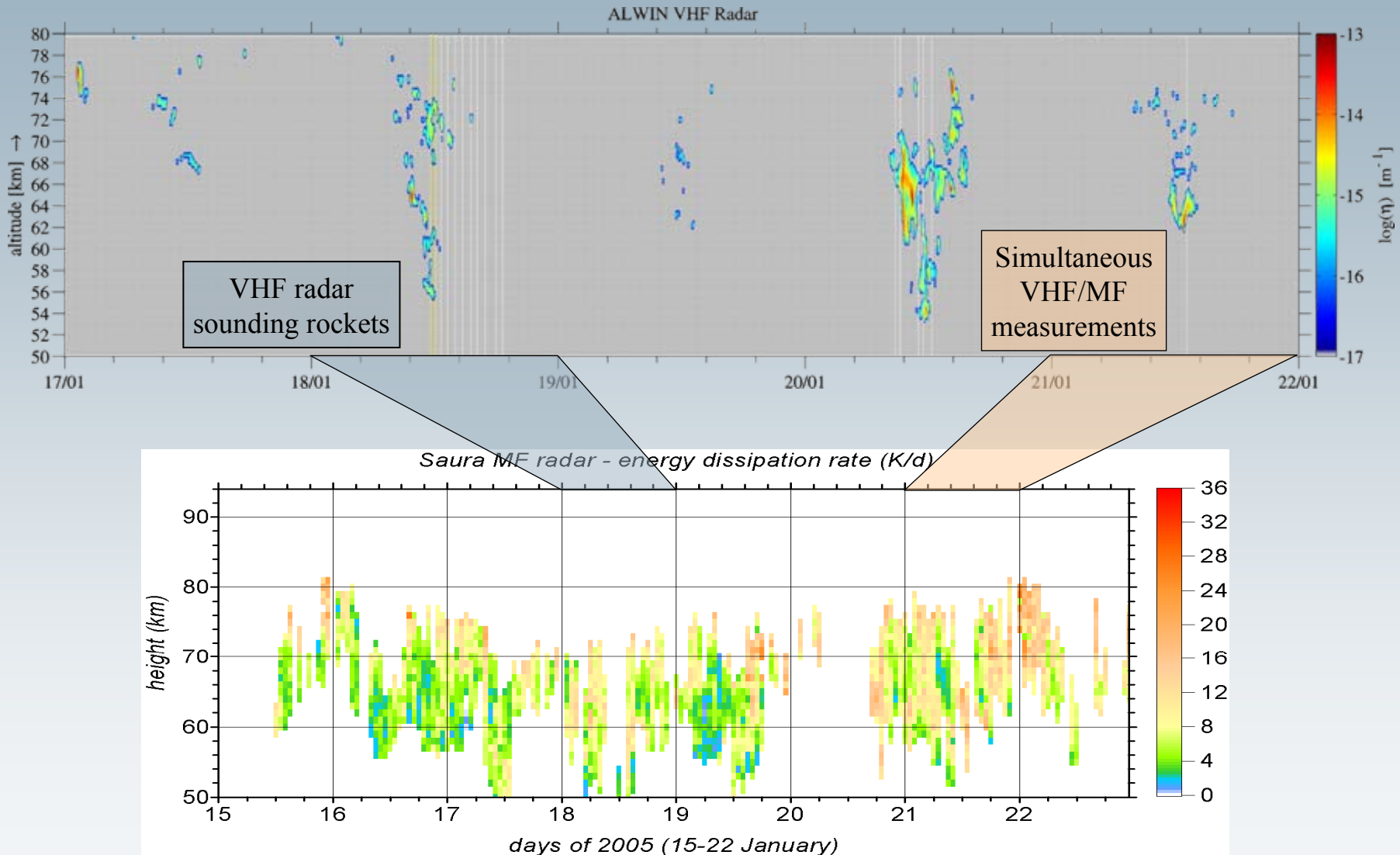


Radar observations & rocket experiments at Andenes



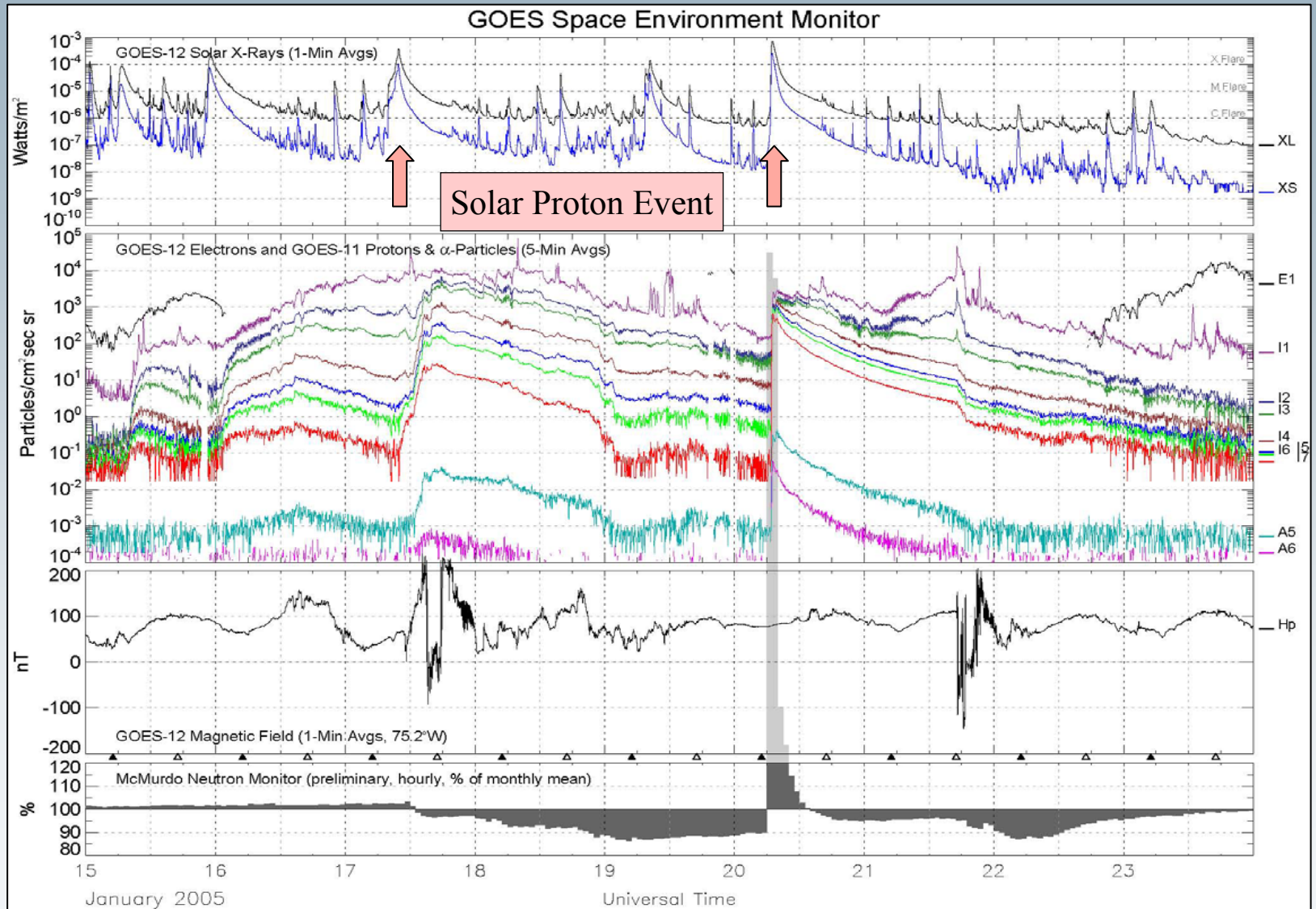
- insitu measurements by meteorological & sounding rockets in January 2005
- **ALWIN VHF radar**
 - 53.5 MHz
 - vertical beam, Doppler & spaced antenna
 $\Delta h = 300$ m,
 - absolutely calibrated reflectivity
- **Saura MF radar**
 - 3.17 MHz
 - narrow beam Doppler radar (width $\sim 7^\circ$)
 $\Delta h \sim 1.5$ km,
 - Doppler winds
 - turbulence from spectral width
 - electron density

Simultaneous and co-located measurements of PMWE and turbulence by VHF and MF radars on January 17 - 21, 2005



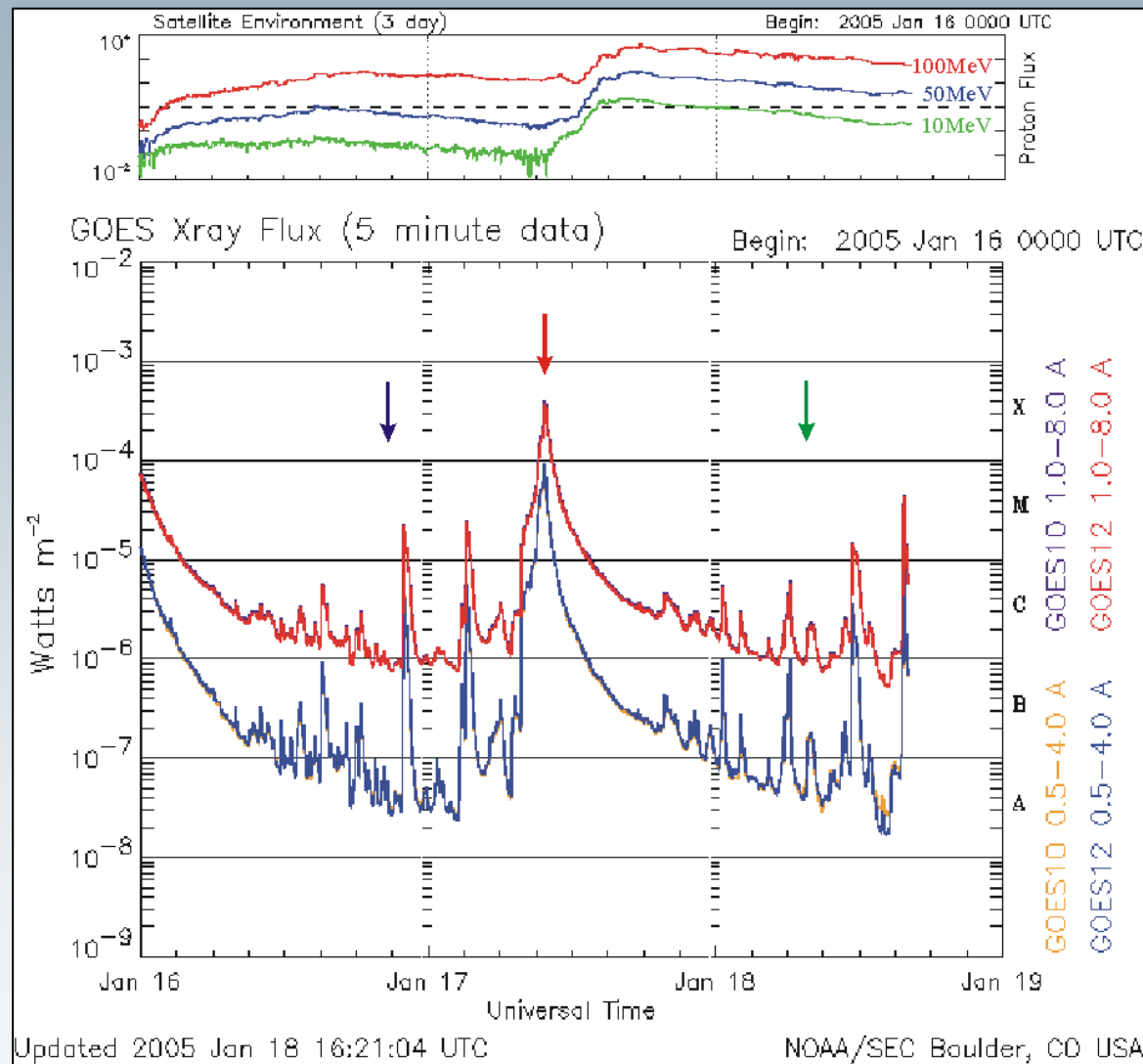
Solar activity after observations of the GOES-satellite

increased x-ray radiation and highly energetic protons on 17 and 20 Jan. 2005



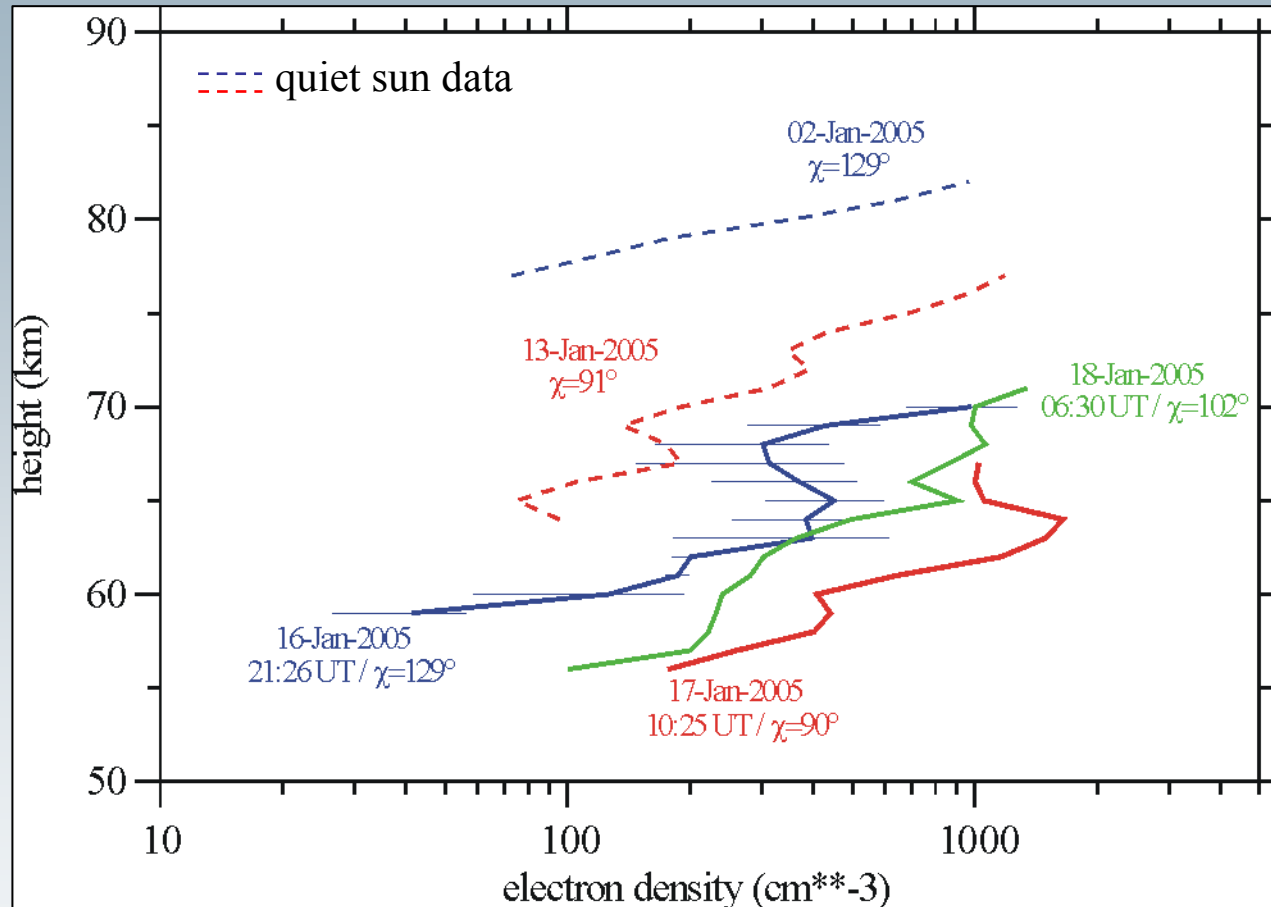
Solar proton fluxes and s-ray fluxes on January 17, 2005

before, at the peak, and after the solar activity event



Electron densities on January 17, 2005

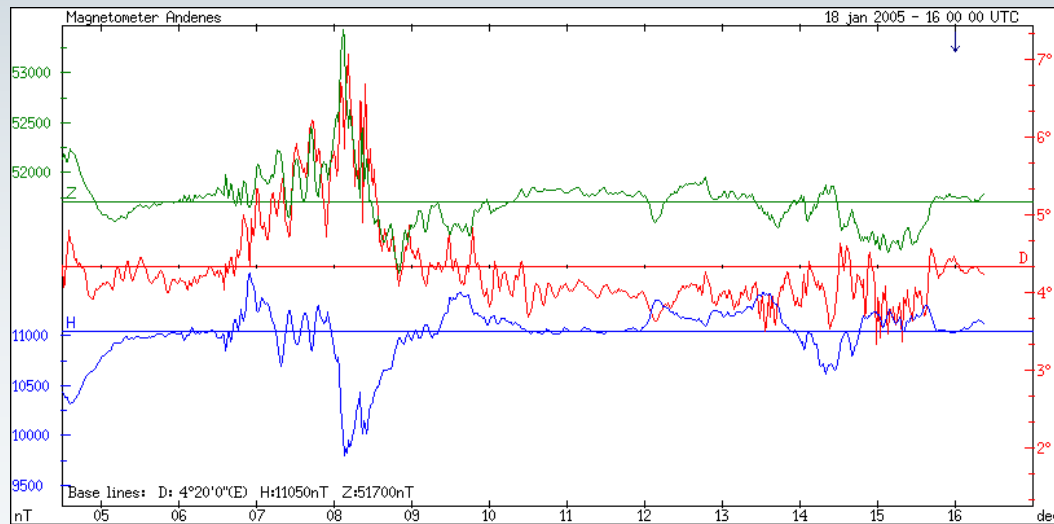
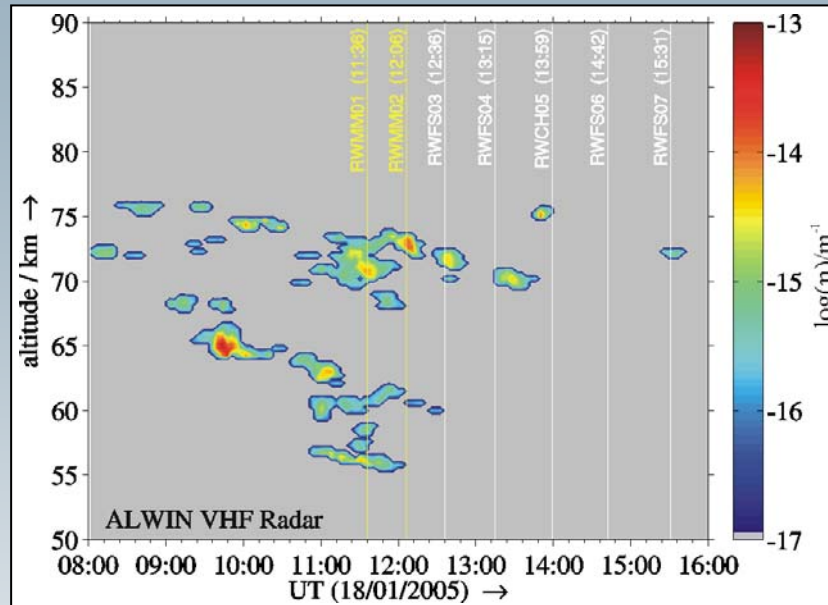
before, at the peak, and after the solar radiation storm



enhanced electron densities on **January 18** due to enhanced proton fluxes

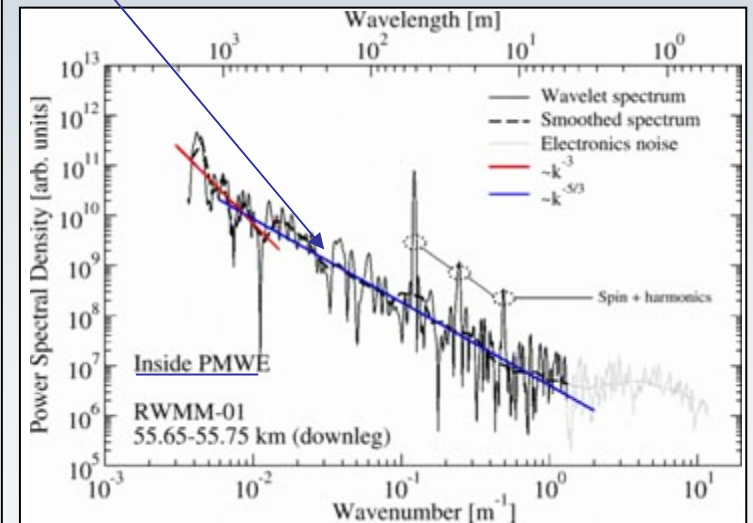
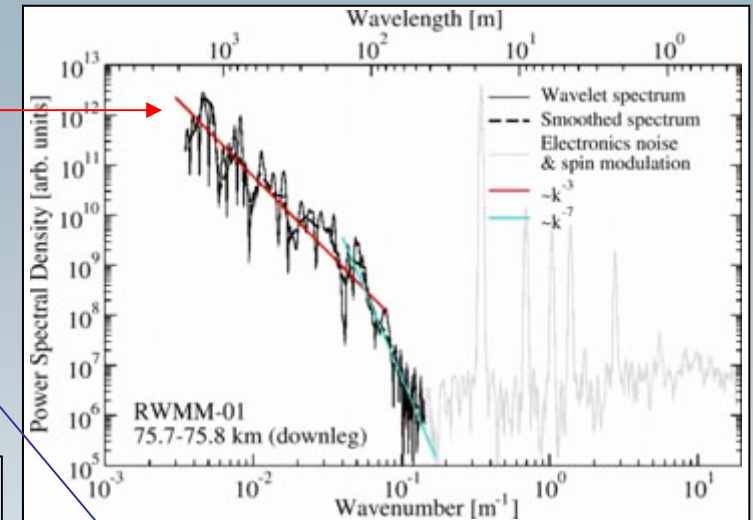
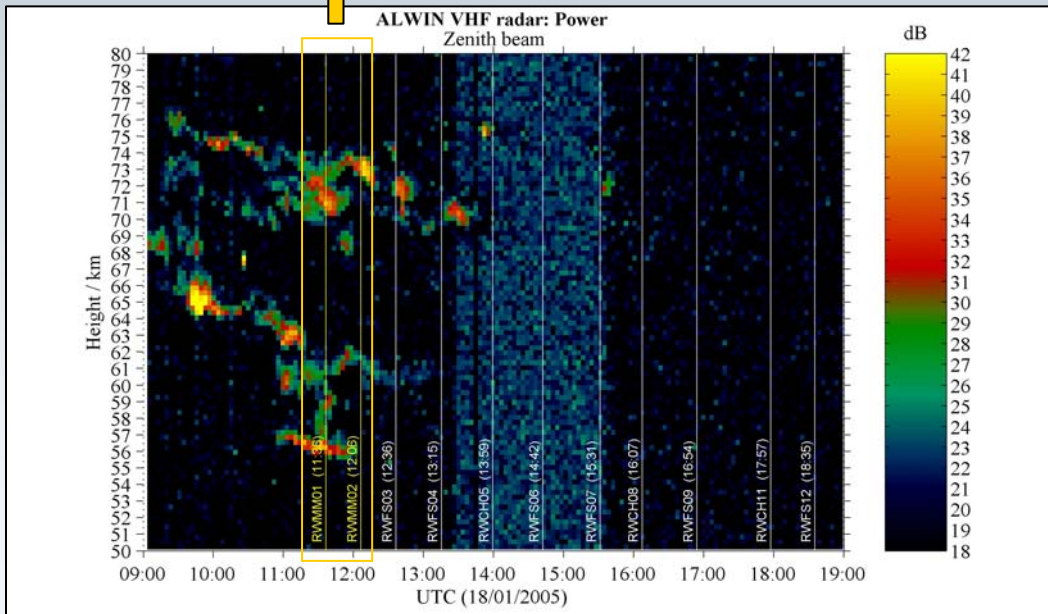
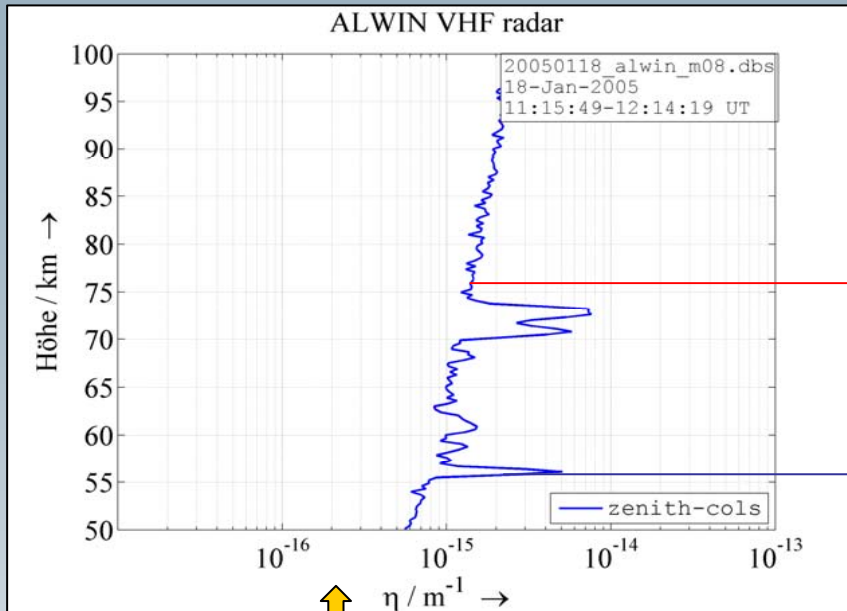
PMWE on January 18, 2005

onset of a geomagnetic storm on 08:00 UT !



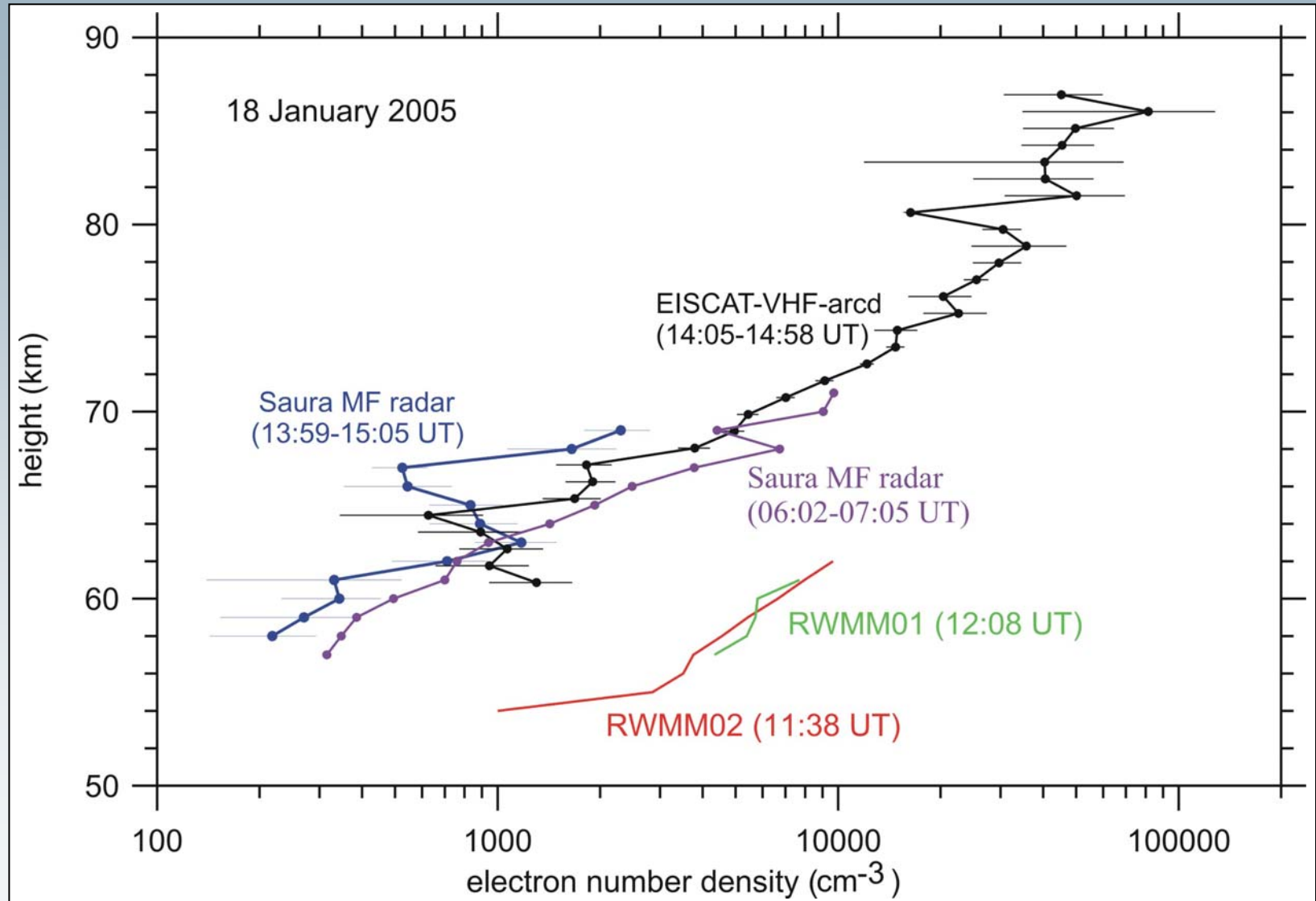
PMWE on January 18, 2005

Brattli et al., ACP, 6, 5515-5524, 2006

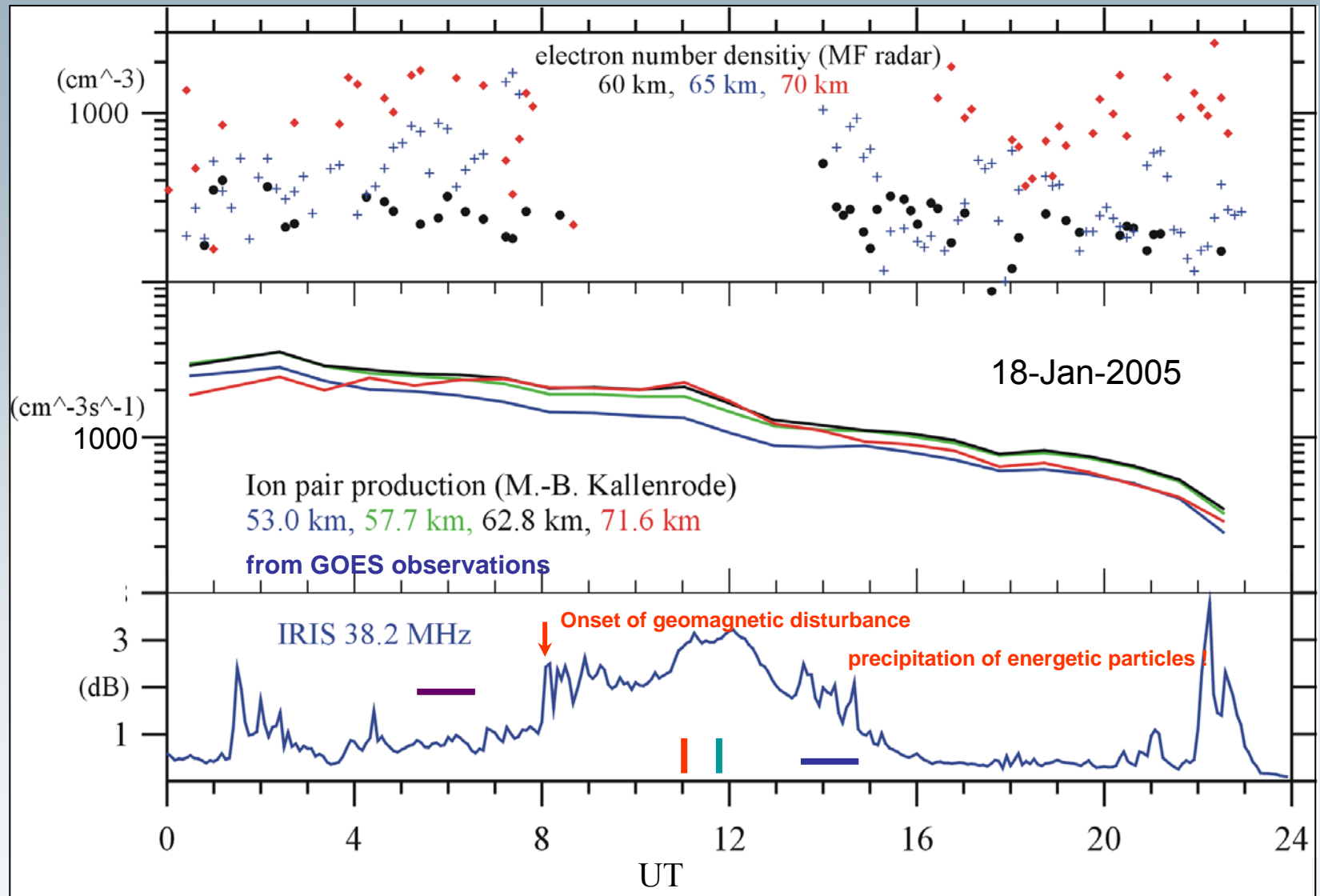


PMWE on January 18, 2005

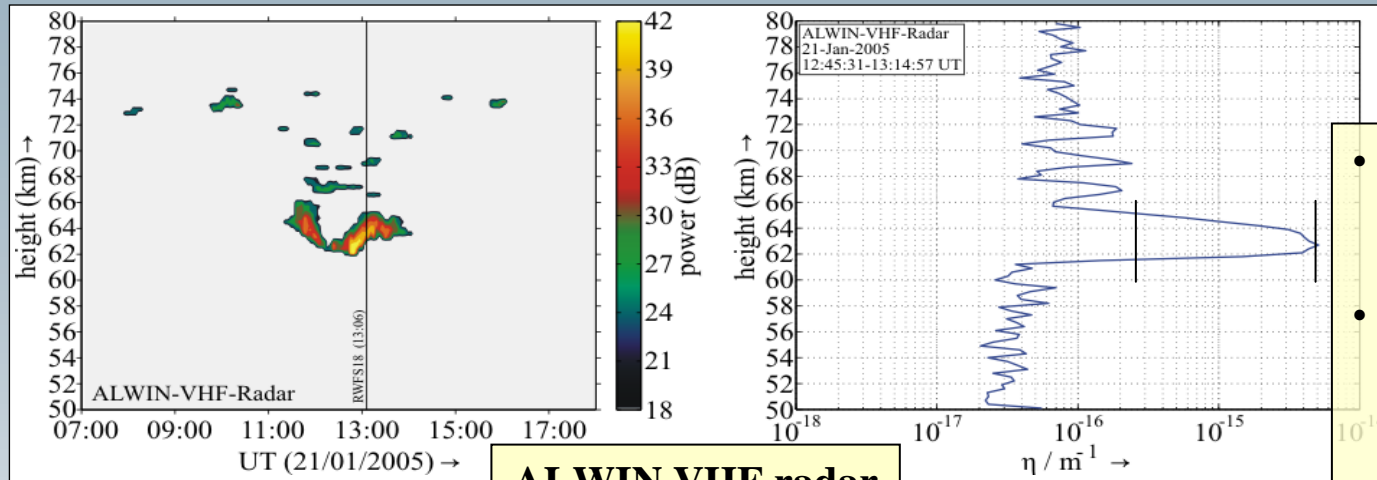
Electron density profiles by radar and insitu radio wave propagation measurements



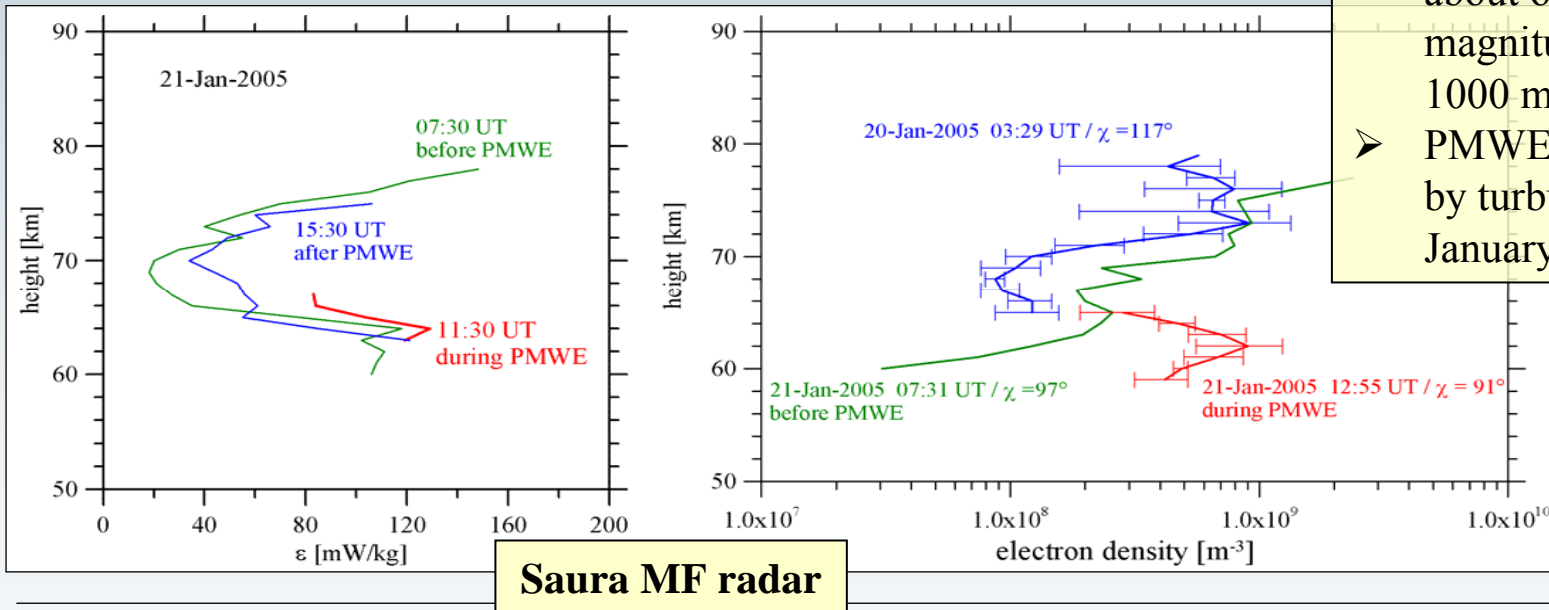
PMWE on January 18, 2005




Simultaneous observations of radar reflectivity, energy dissipation rates and electron densities during PMWE on January 21



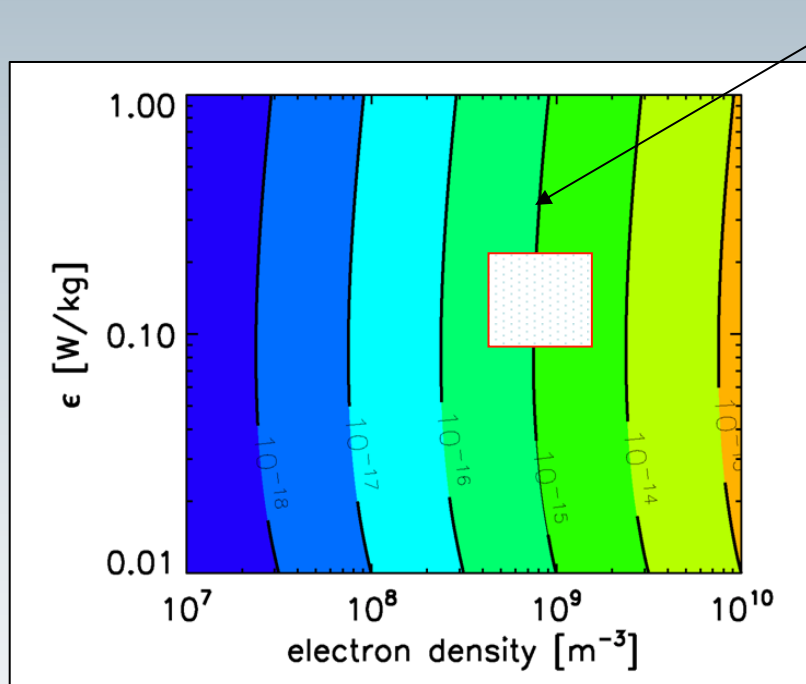
- Turbulence is always present around 65 km
- strong PMWE appear after enhancement of electron density by about one order of magnitude to 400 ... 1000 m^{-3}
- PMWE's are caused by turbulence (on January 21, 2005)



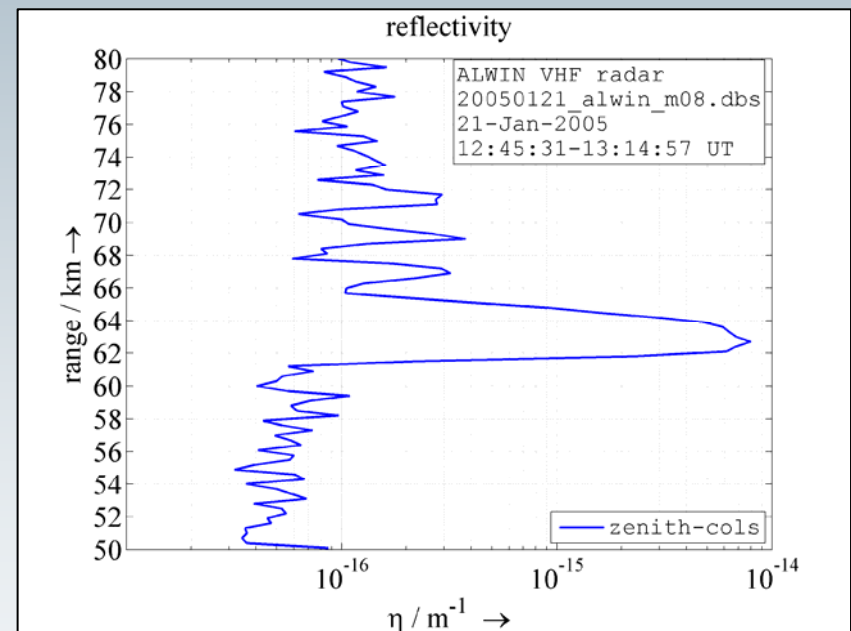
Comparison of radar results (ϵ , N_e , η) with model calculations of coherent radar backscatter from turbulent PMWE (Lübken et al., ACP,13-24, 2006)

 model values of radar reflectivity η resulting from electron densities and turbulent energy dissipation rates ϵ measured with the Saura MF radar

η (model) \sim η (ALWIN radar) ! \rightarrow PMWE is caused by turbulence

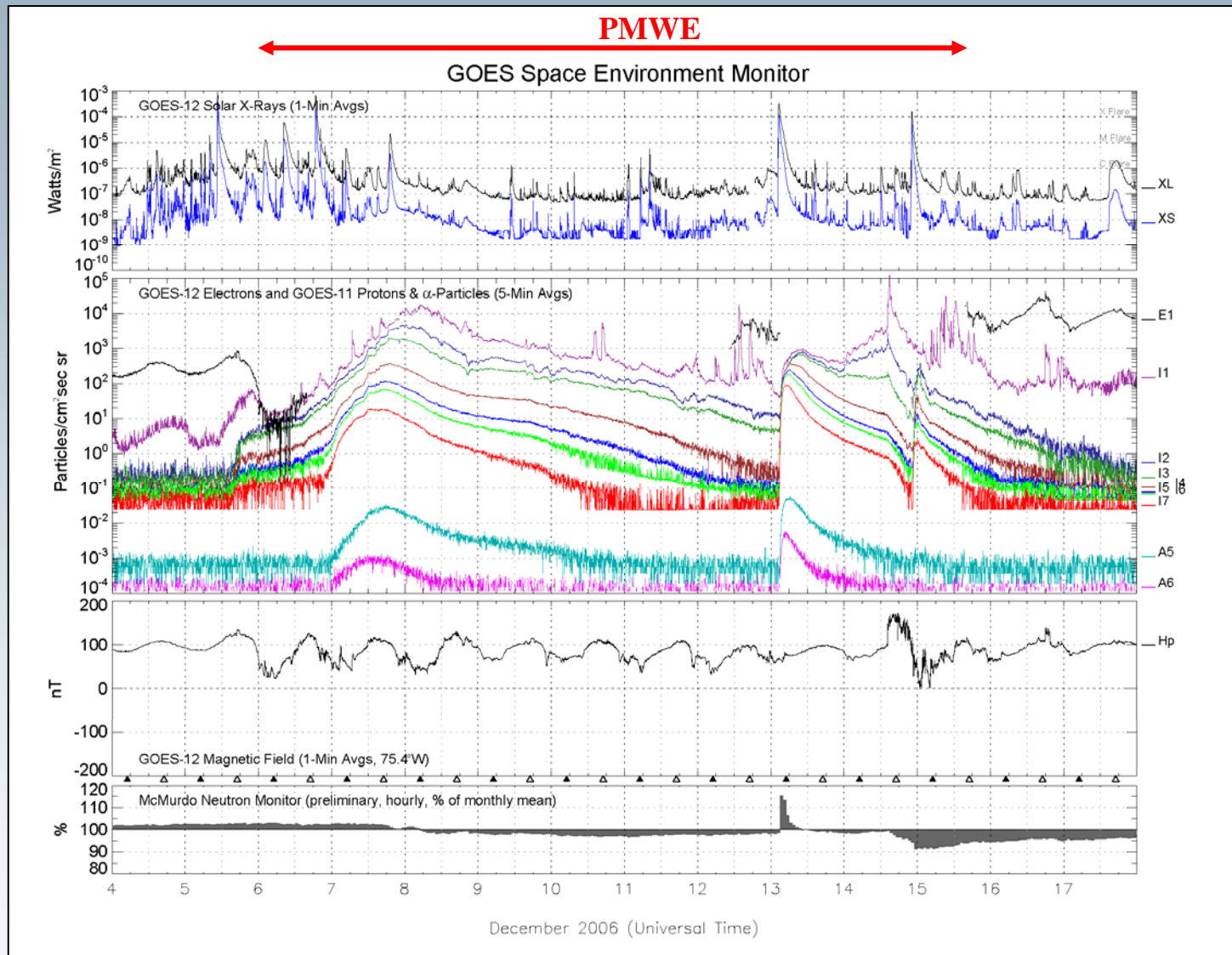


Model results of radar reflectivity from coherent radar backscatter @ 60 km height (Lübken et al., 2006)



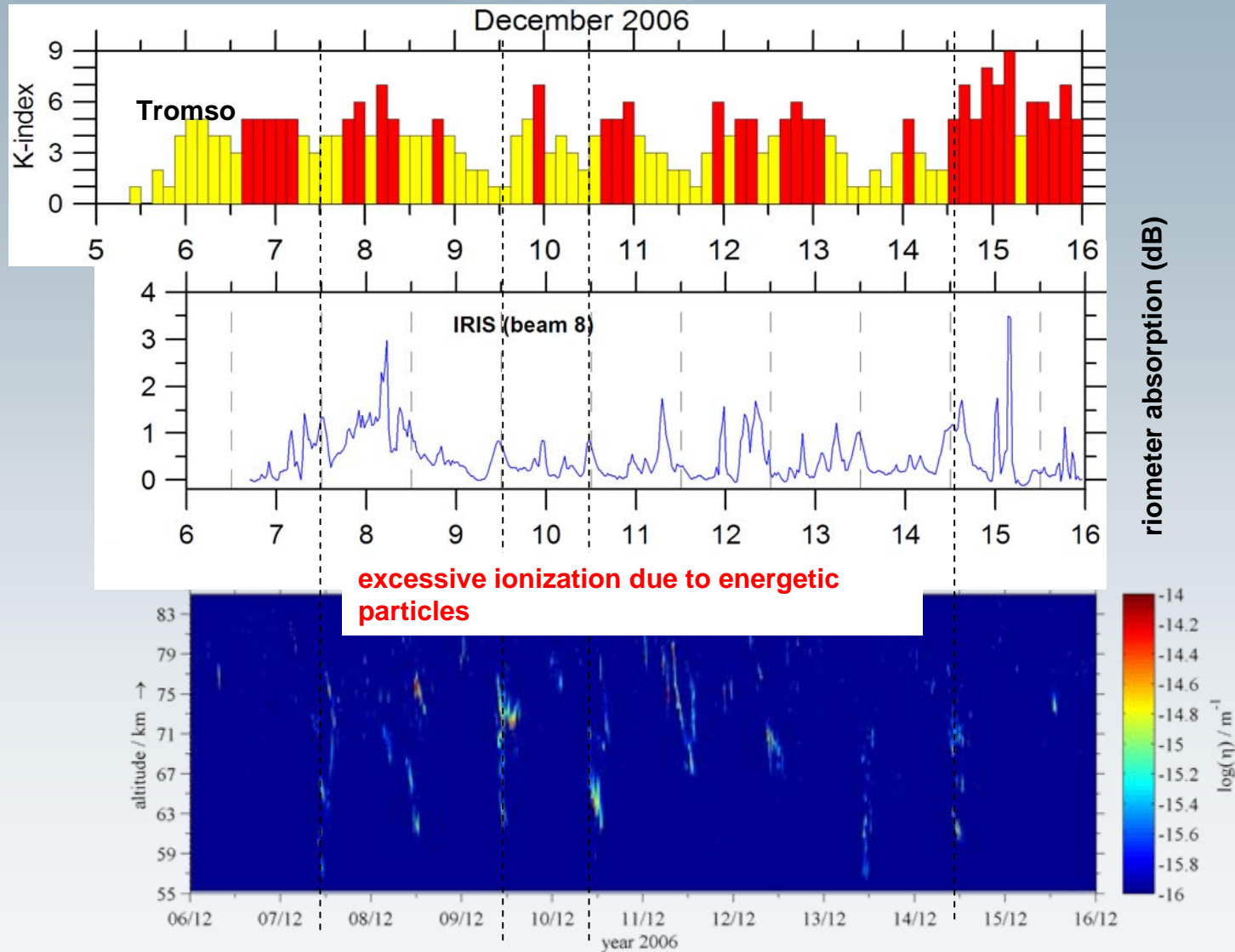
Volume reflectivity estimated with the ALWIN VHF radar

Recent PMWE observations on 2006, December 6 – 15



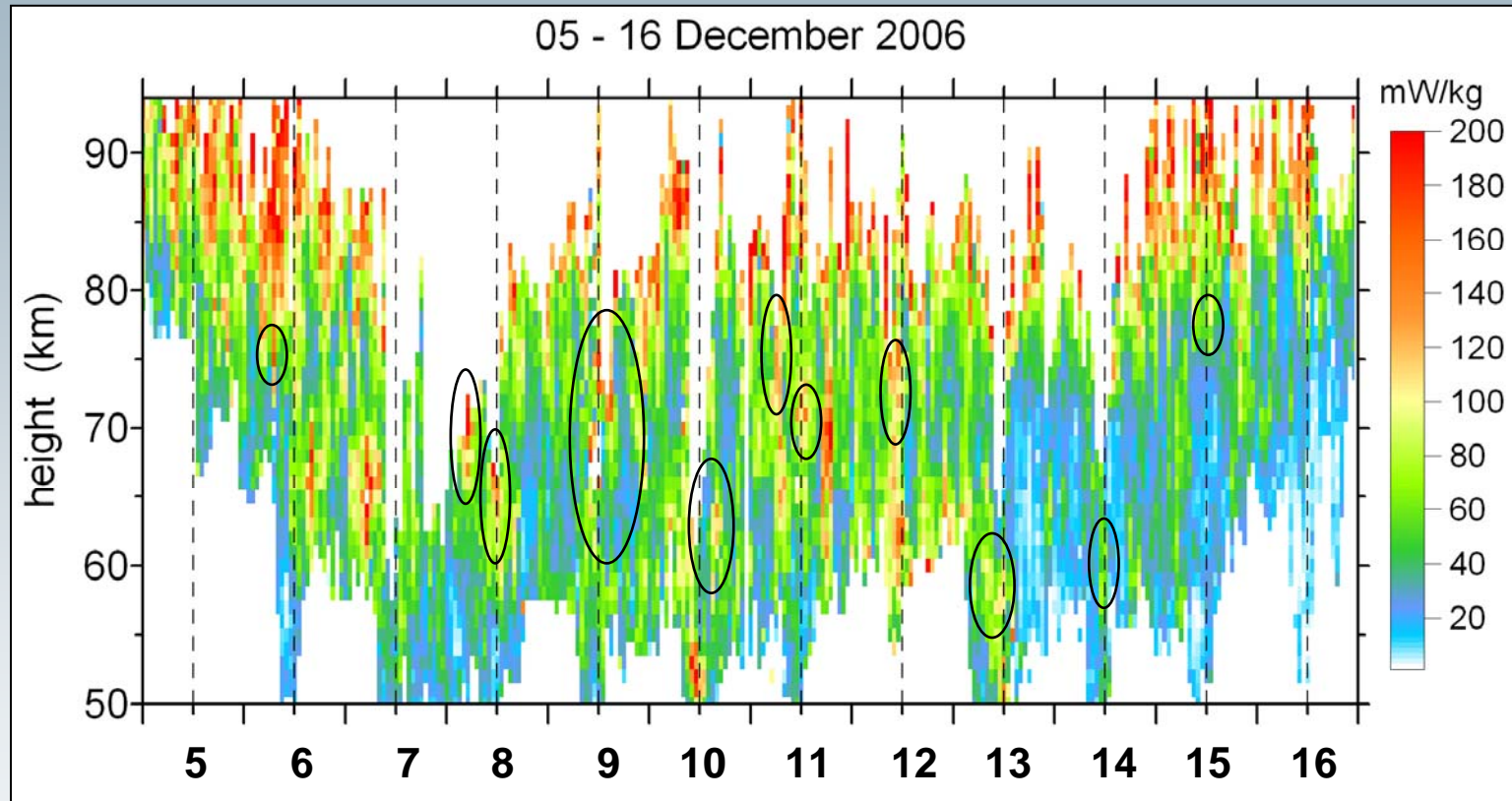
Recent PMWE observations on 2006, December 6 – 15

excessive ionization due to energetic particles



Recent PMWE observations on 2006, December 6 – 15

turbulent energy dissipation rate

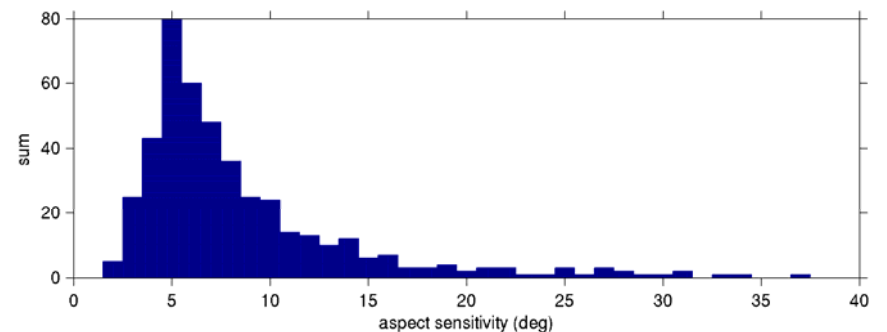
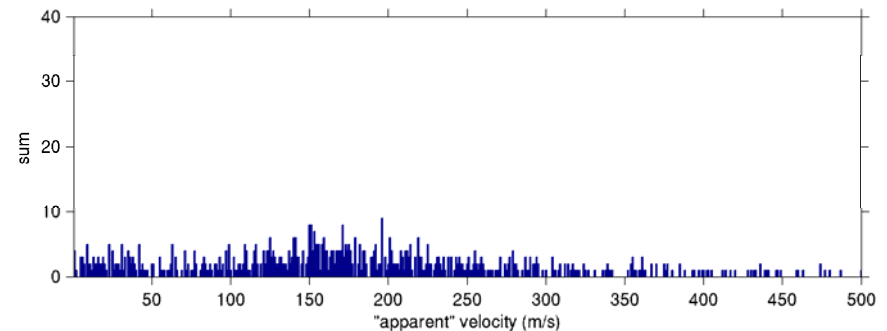
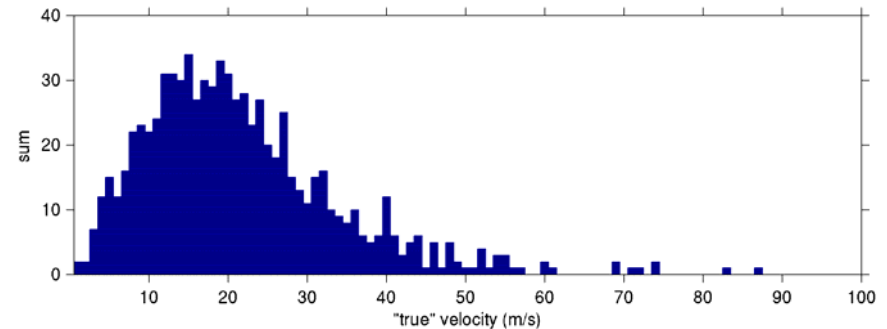


 PMWE

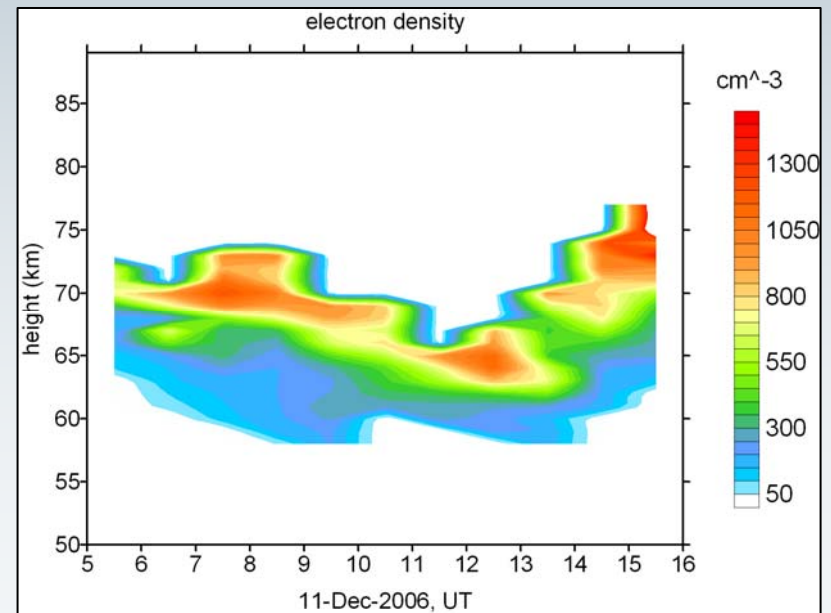
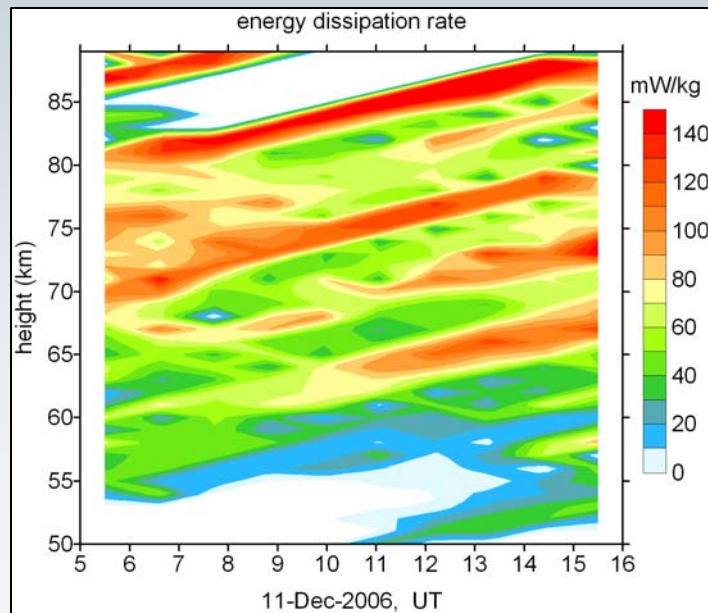
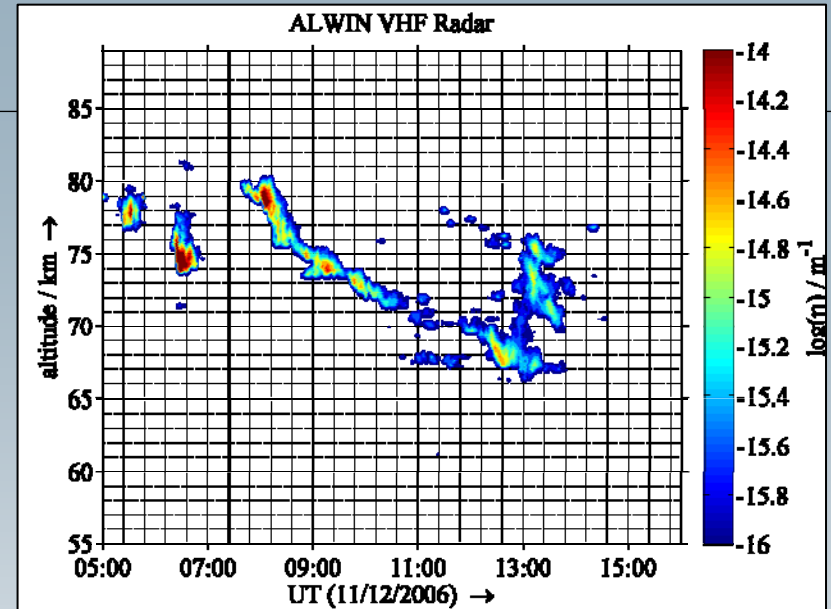
Recent PMWE observations on 2006, December 6 – 15

ALWIN VHF radar – spaced antenna observations

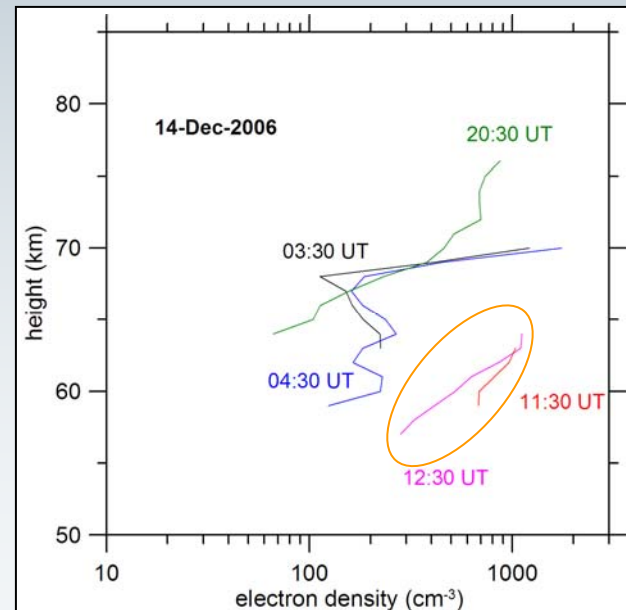
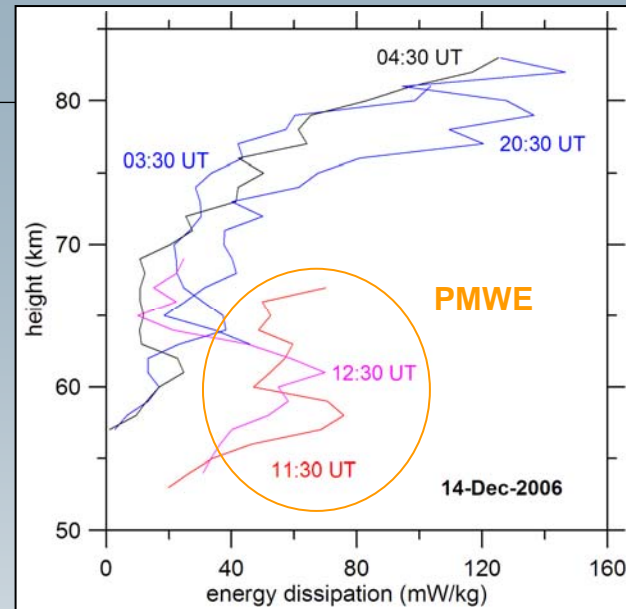
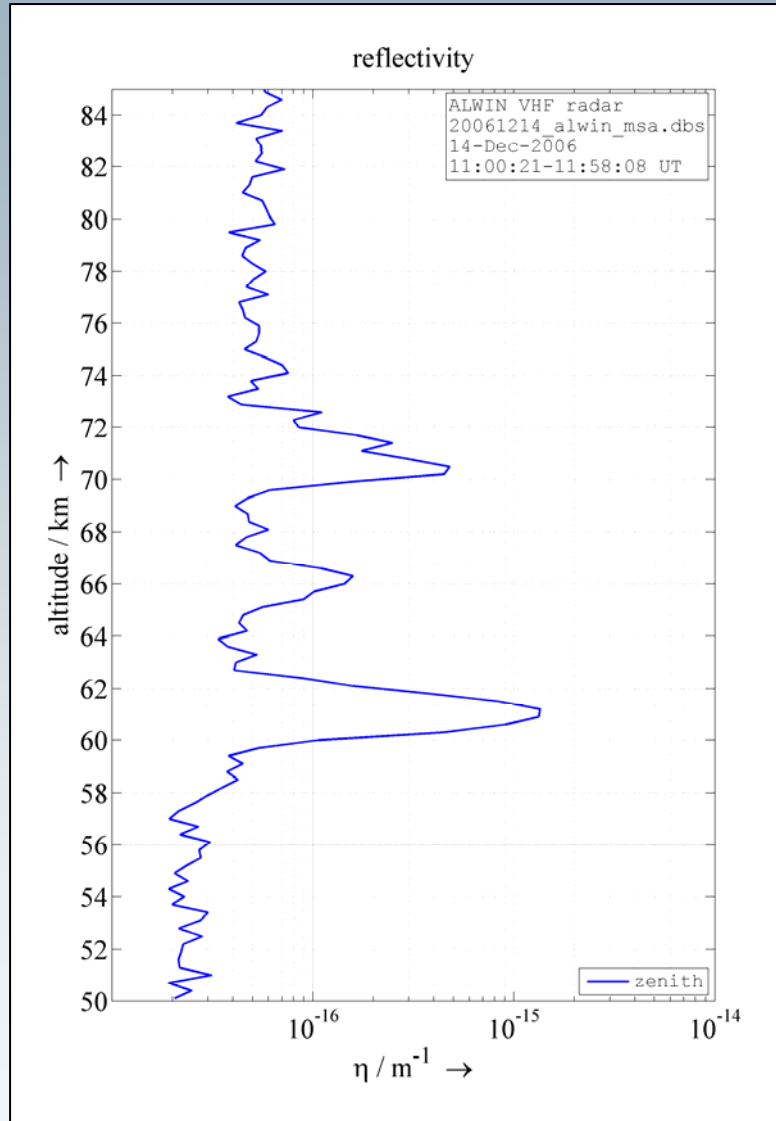
- **Full Correlation Analysis (FCA)**
 - without thresholds
 - apparent and true velocities,
 - aspect sensitivity θ_s
- **no indications of**
 - horizontal velocities > 100 m/s
 - specular reflections $\theta_s < 3^\circ$



PMWE on December 11, 2006



PMWE on December 14, 2006



Summary

- The Saura MF radar provides estimates of energy dissipation rates and electron densities in the altitude range from 50 km to about 90 km with a time resolution of 1 hour since September 2003.
- PMWE are observed at altitudes between 55 and 75-80 km with radar reflectivities between $\eta \sim 10^{-16} - 10^{-13} \text{ m}^{-1}$
- Turbulent energy dissipation rates are $\sim 100 \text{ mW/kg}$ around the PMWE events
- The electron density is increased by about one order of magnitude to about $10^9 \text{ electrons/m}^{-3}$ at altitudes between 55 and 70 km
- Simultaneous observations of energy dissipation rates, electron densities (Saura MF radar) and absolute radar reflectivities (ALWIN VHF radar) during the occurrence of PMWE indicate that **these PMWE are caused by turbulence.**