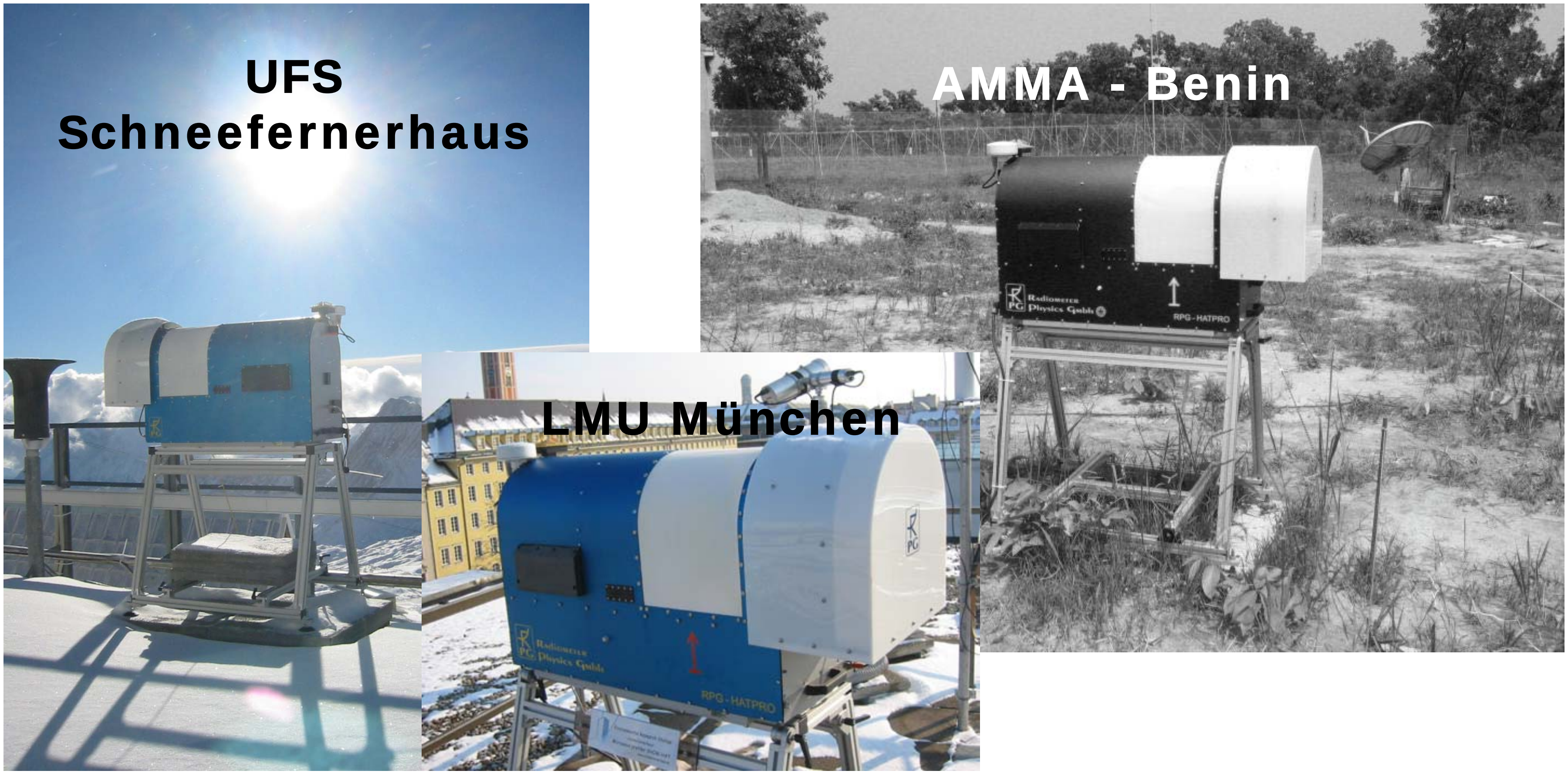
Boundary layer temperature profile observations using ground-based microwave radiometers



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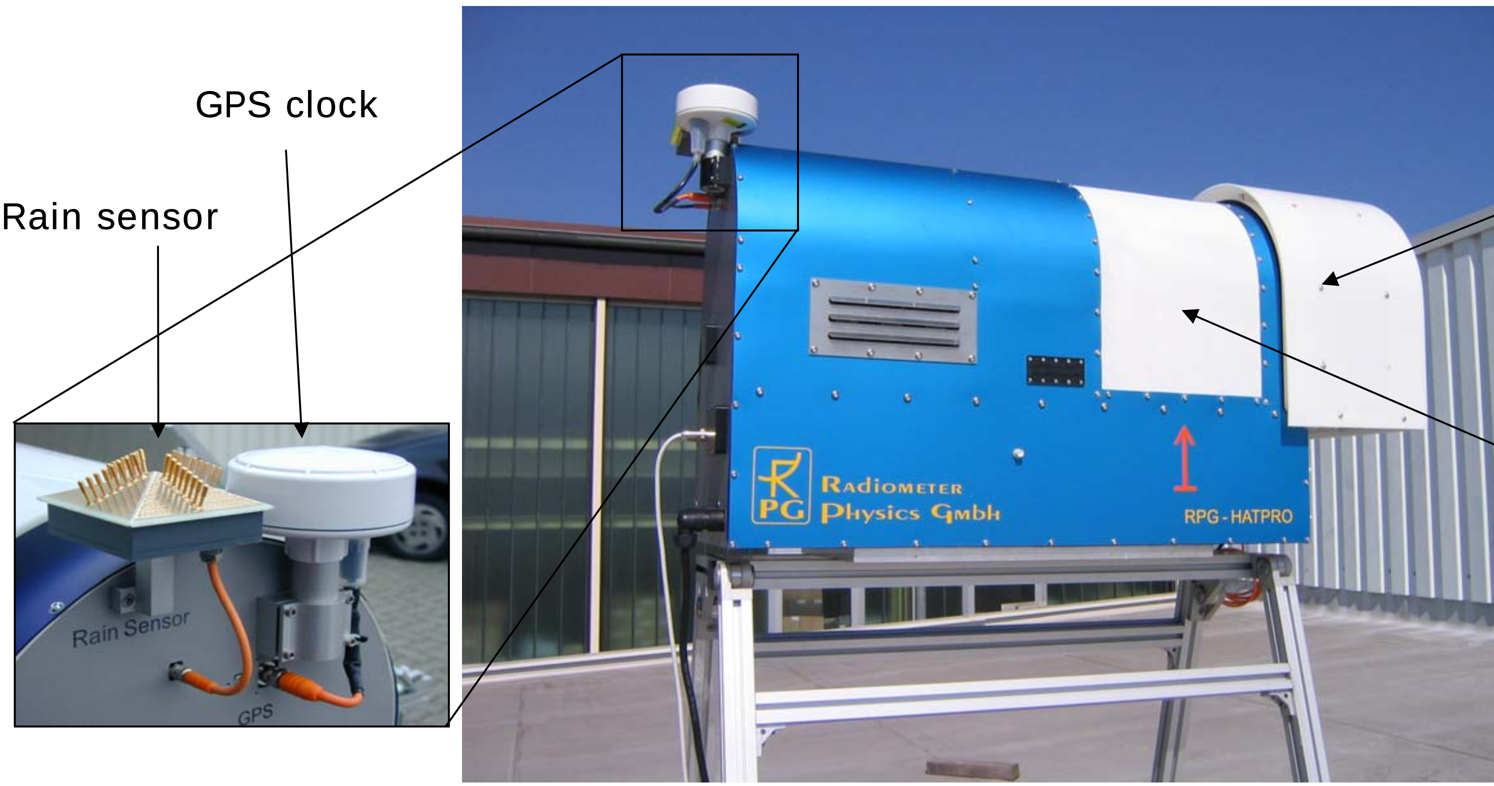
universitätbonn
Meteorologisches Institut der Universität München
RPG

Instrumentation / Theory

HATPRO microwave profiler

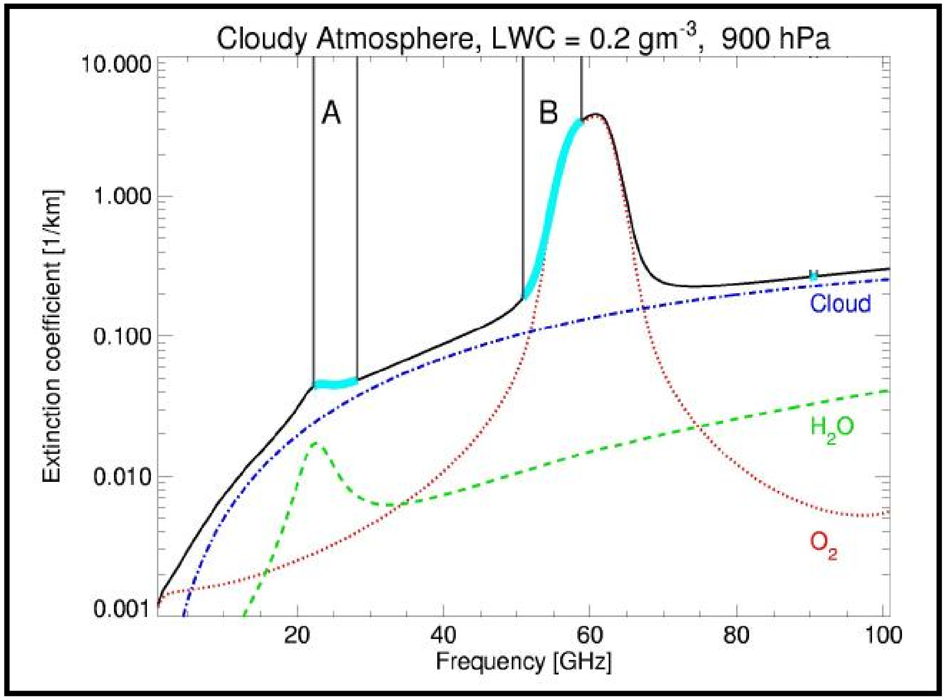


What does HATPRO measure?

- Continuous measurements of thermal emission by atmospheric components at 14 frequencies (see below) expressed as brightness temperatures.

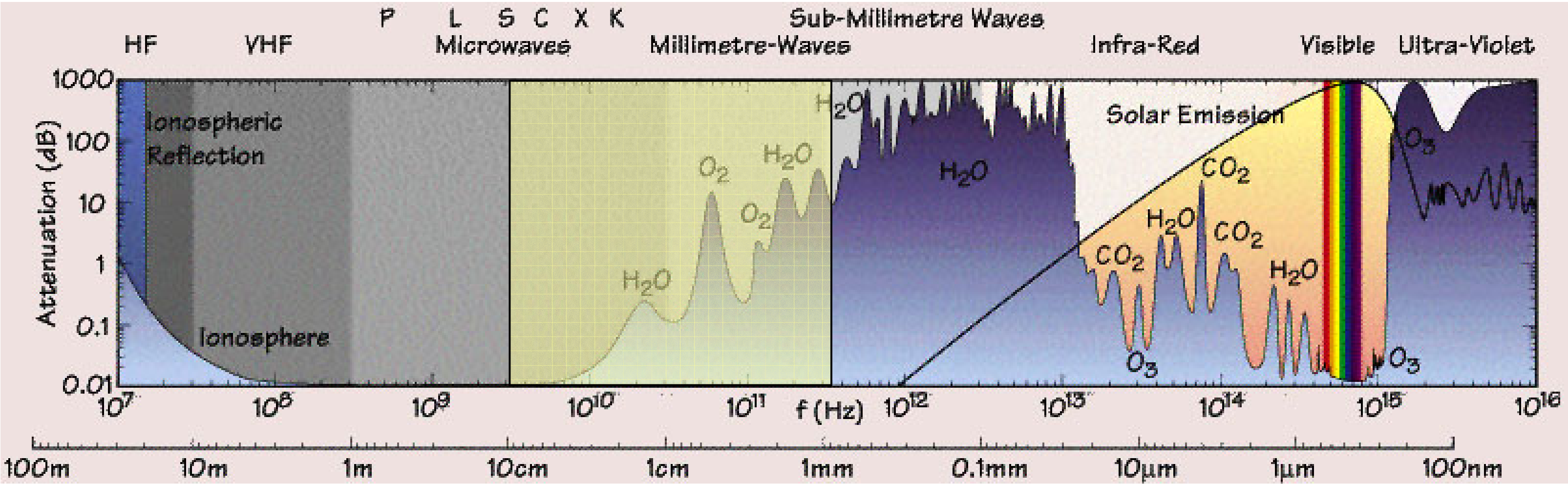
A: 22.235 –31.4 GHz, 7 channels at the water vapor line and the atmospheric window

B: 51.26 – 58.0 GHz, 7 frequencies at the oxygen absorption line



Instrumentation / Theory

Microwave spectrum



- Distinct microwave absorption characteristics of H_2O and O_2 between 1 and 200 GHz
- Clouds are semi-transparent → observations of cloud properties as well as temperature and humidity profiles possible
- Higher absorption of clouds at higher frequencies

Zenith observations

HATPRO: two different operation modes

vertical measurements

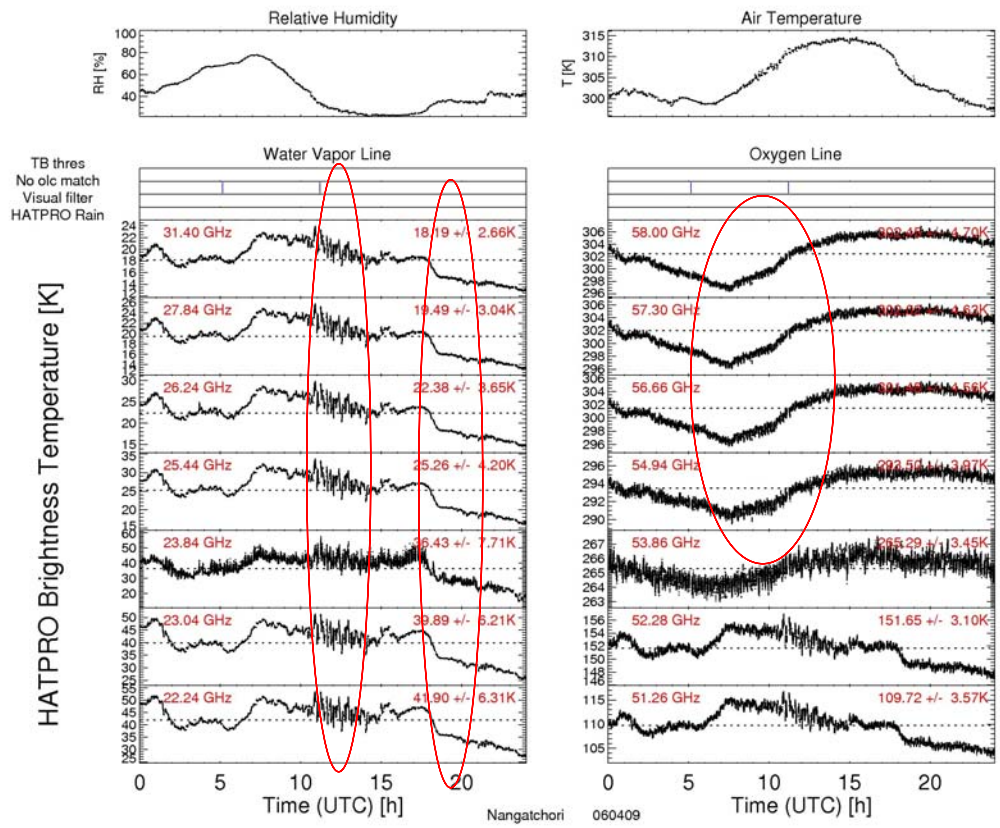
- High temporal resolution (1 sec)
- Simultaneous observation of all 14 channels

Products:

- Retrieval of LWP (liquid water path) and IWV (integrated water vapor)
- Temperature profiles up to 10 km altitude
- Humidity profiles up to 5 km

Retrievals:

- Statistical retrieval algorithms are developed on the basis of a large set of atmospheric profiles observed by radiosondes



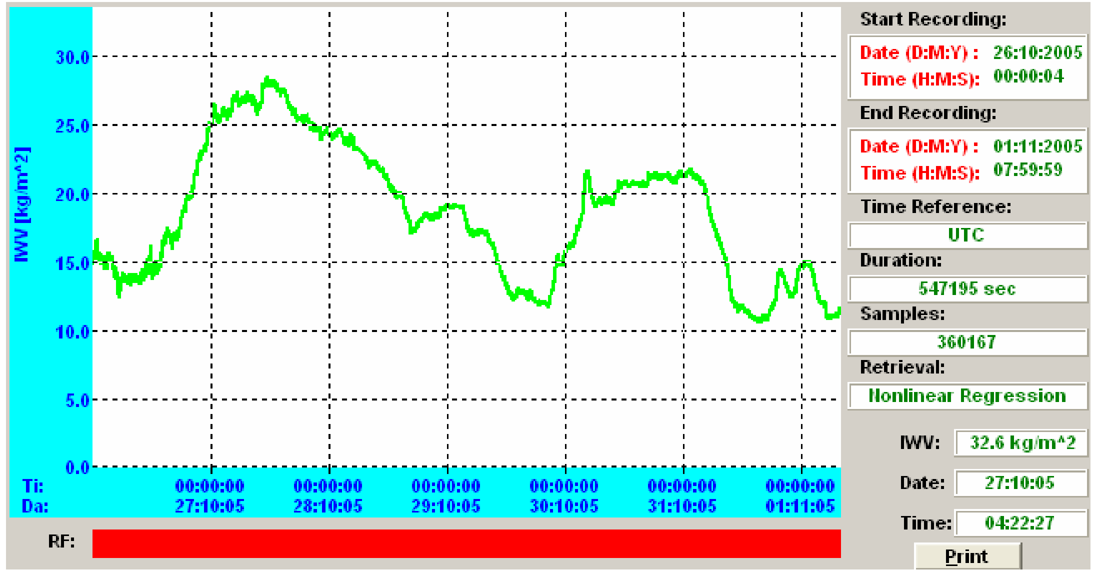
Zenith Observations

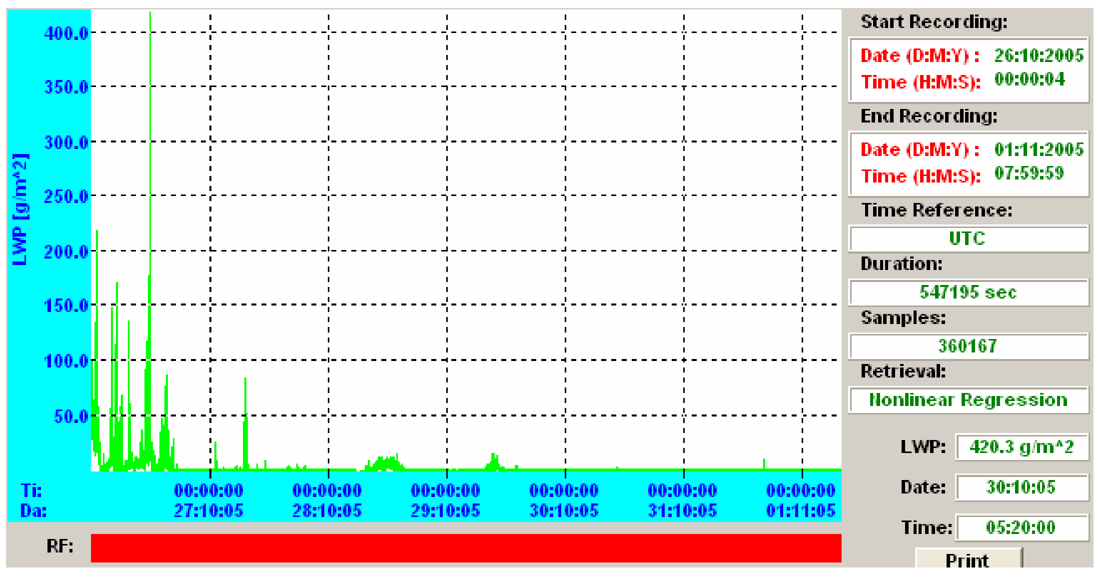
Time series of
IWV (Integrated water vapor) and
LWP (Cloud liquid water path)

Theoretical accuracy:

<1 kg m^{-2} for IWV

~20 g m^{-2} for LWP





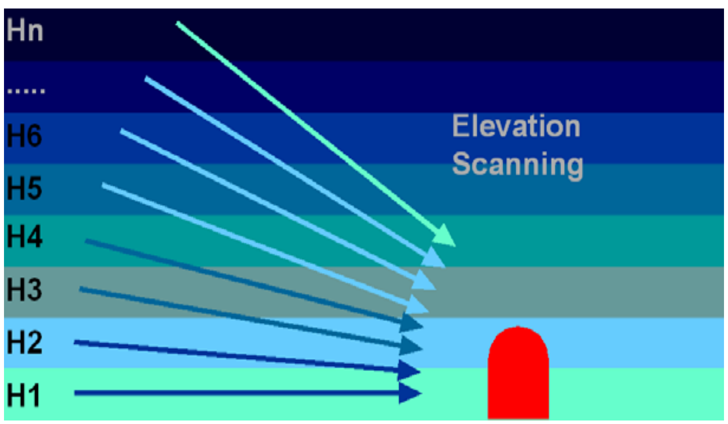
Observations from 26 Oct – 1 Nov 2005 in Lindenberg (IWV top, LWP bottom)

Boundary layer temperature observations

Boundary layer scans

At prescribed intervals (for example 20 min) boundary layer scans can be performed. Assuming horizontal homogeneity the temperature profile can be determined with high vertical resolution

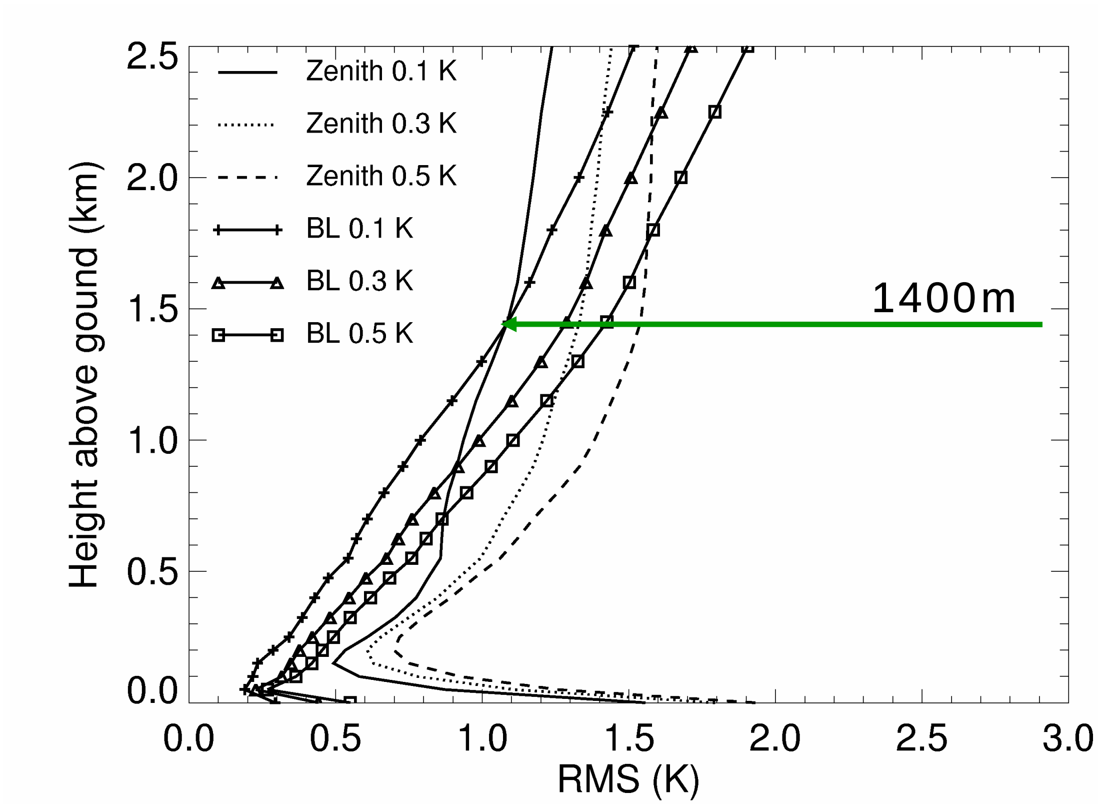
- high receiver stability
- low noise level
- scans between 5° - 90°
- small antenna beam (2° HPBW)
- simple regression algorithms



vertical resolution (< 1km height)
~8m@10m to ~300m@400m

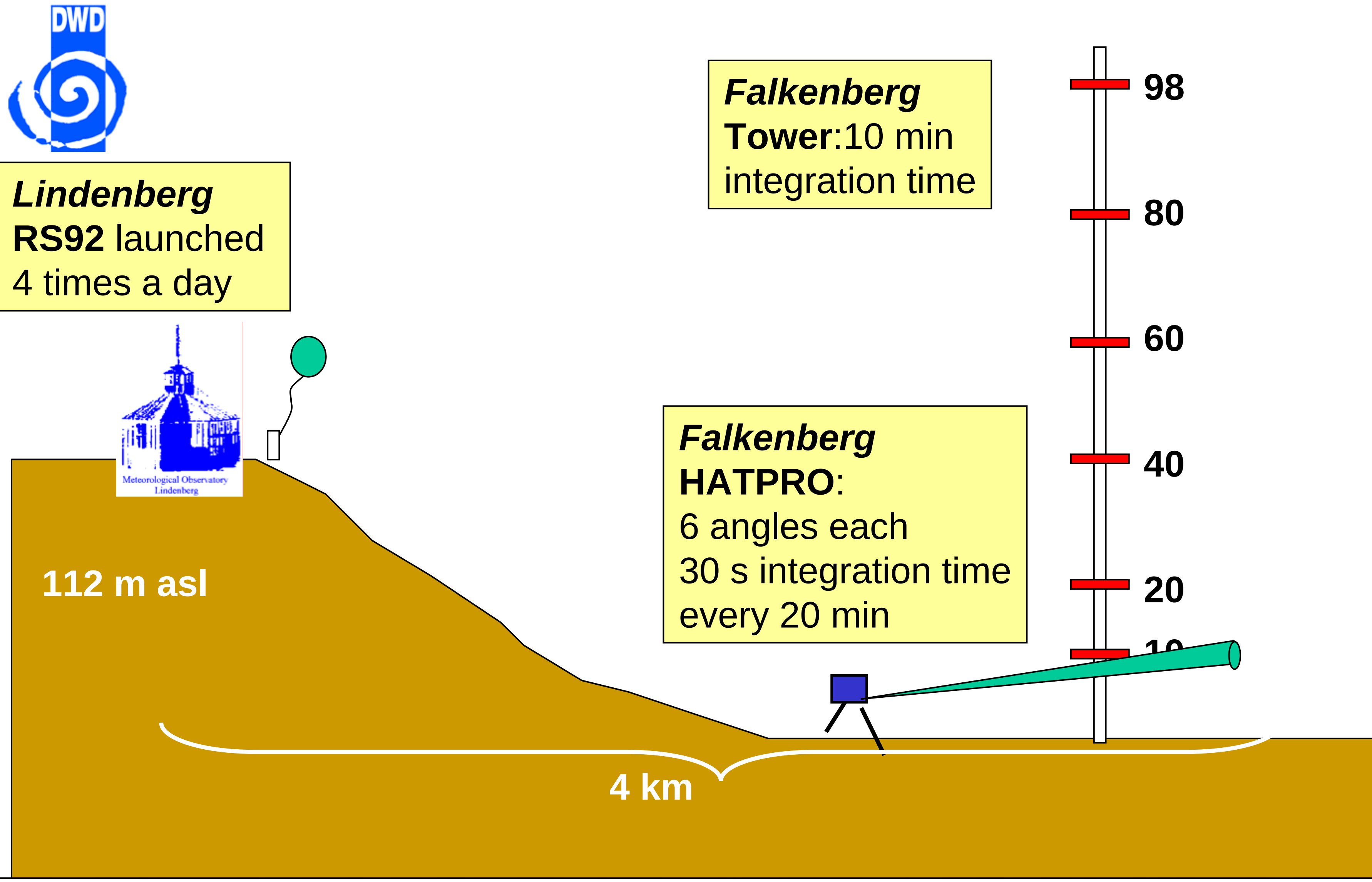
Performance / Accuracy

Accuracy of boundary layer scan retrievals



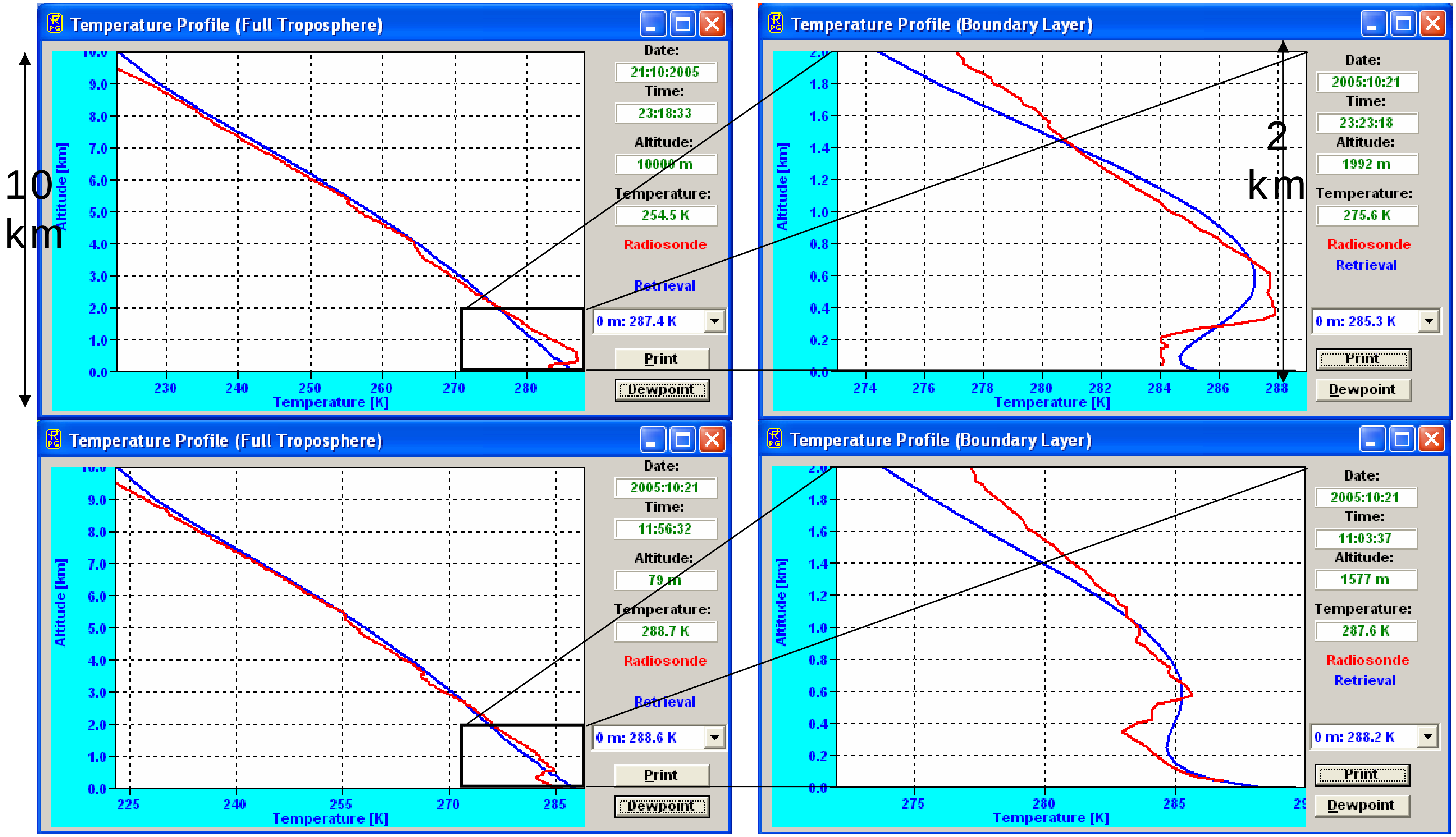
Up to 1400 m above ground, the results can be improved significantly by performing boundary layer scans. Even with a higher noise level angular information provides improved temperature profile

Launch campaign – Comparison setup



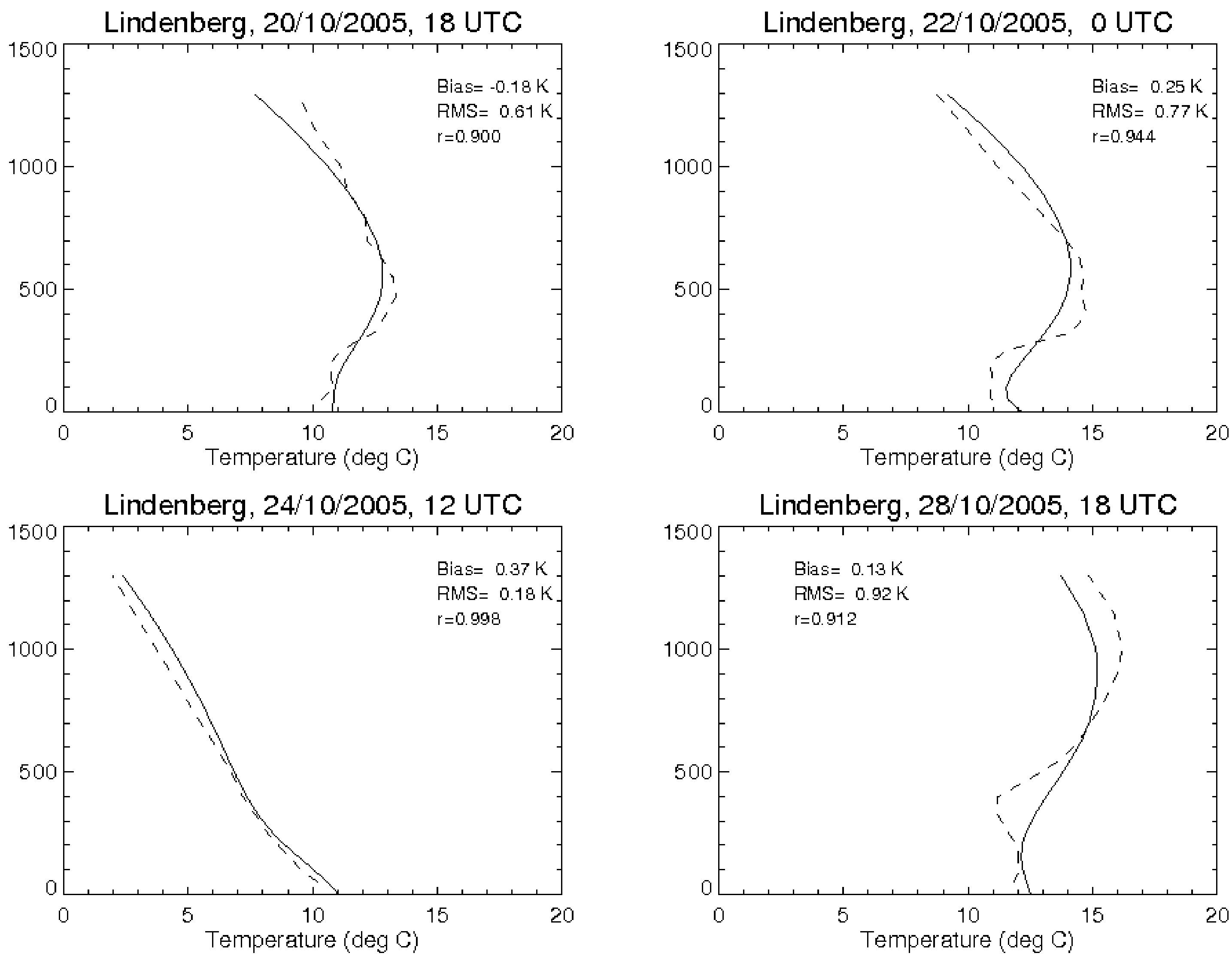
Launch campaign – Falkenberg area

Comparison zenith observations / boundary layer scans



blue: retrieval from HATPRO, red: Radiosounding Lindenberg

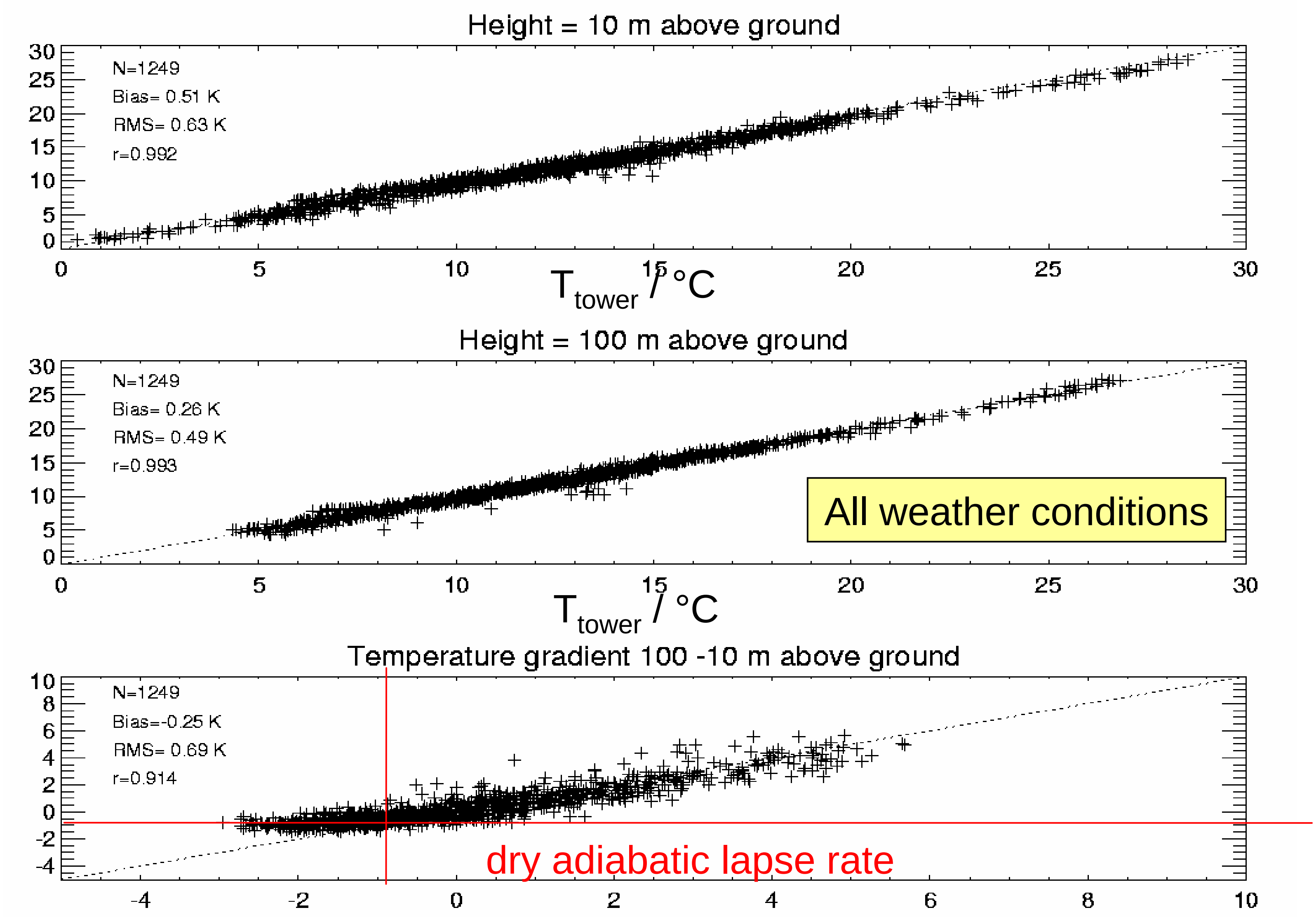
Comparison with Radiosondes



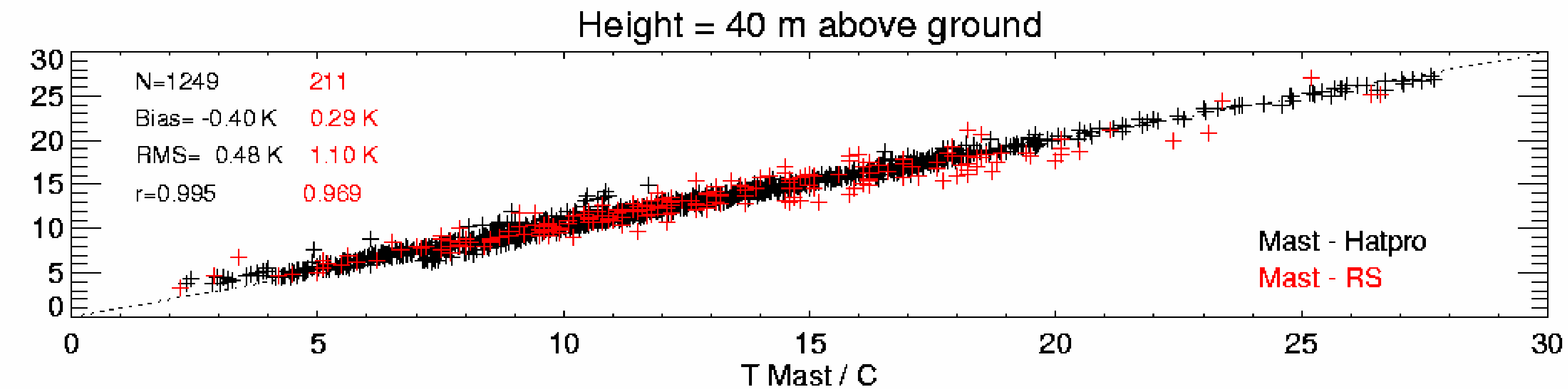
Solid line:
Hatpro profile

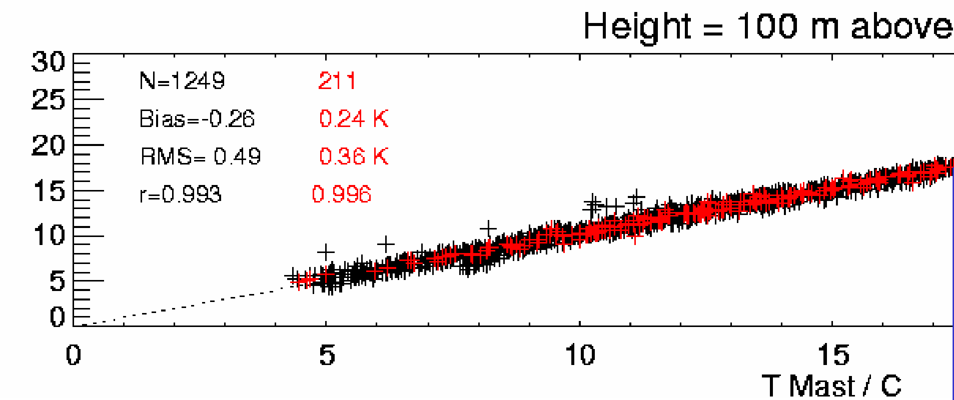
Dashed line:
Radiosonde
measurements

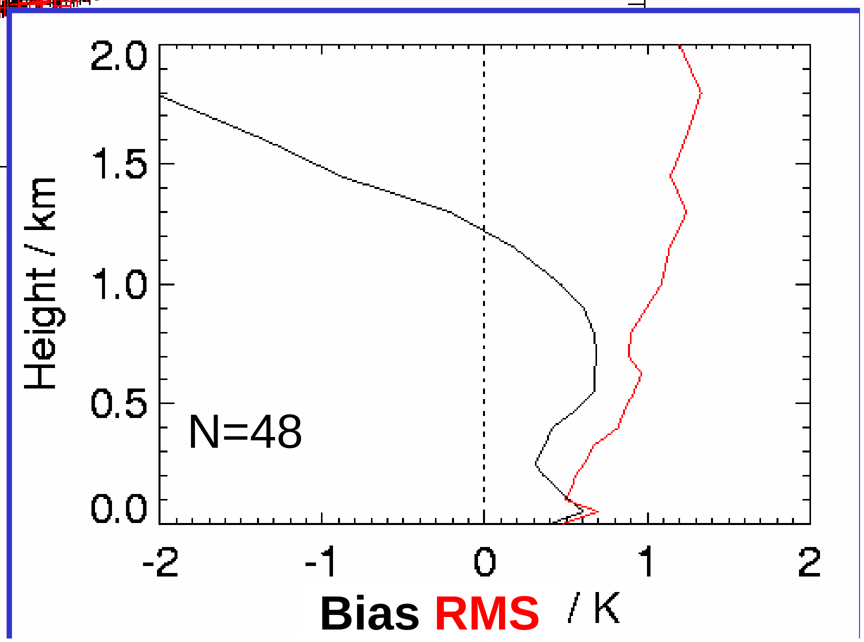
Comparison with tower



Comparison with tower and RS



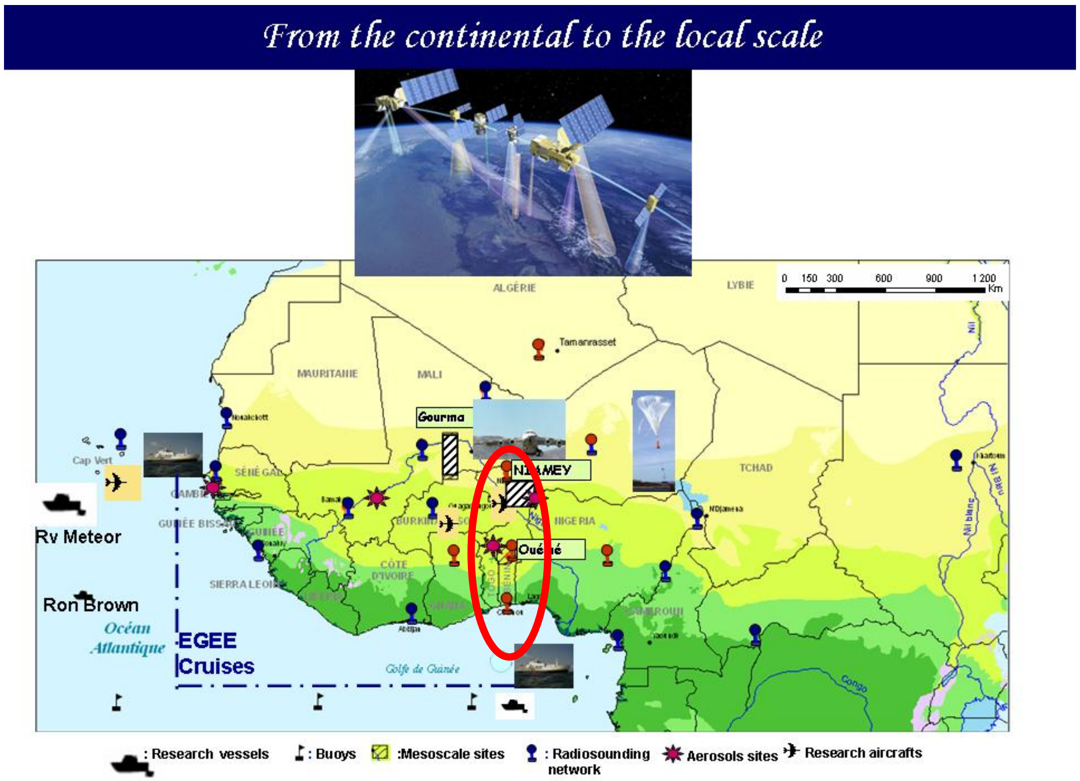




- RMS between RS & HATPRO lower than 1 K below 1 km
- slightly depends on wind direction
- lower inversion strength is well detected
- 6 angle retrieval performs much better than 5

AMMA

AMMA (African Monsoon Multidisciplinary Analysis)



HATPRO measurements in Benin since January 2006

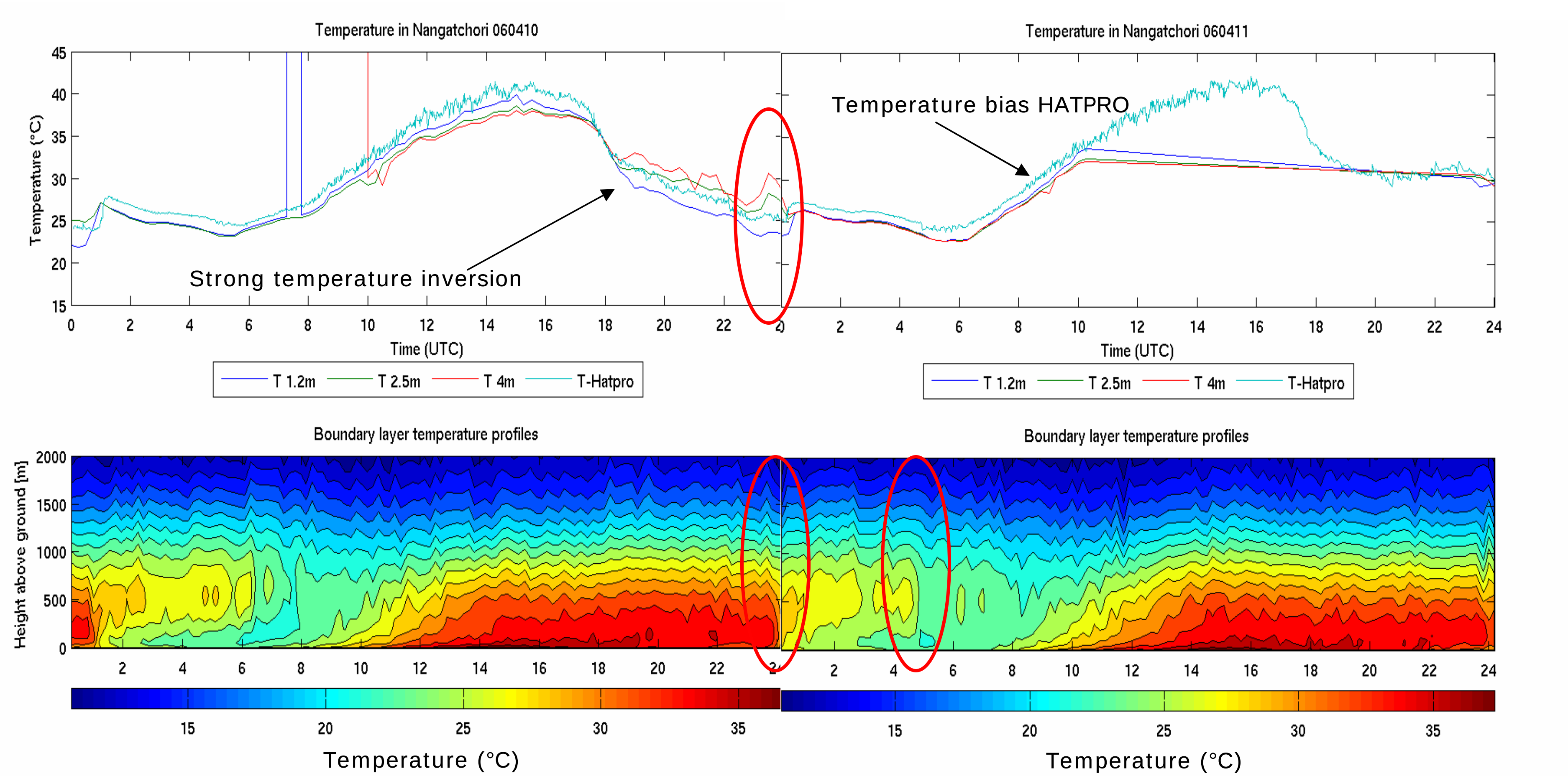
Goals:

- better understanding of processes in tropical boundary layer
- boundary layer height
- temperature profiles in connection with dry and moist air masses
- humidity variations
- cloud liquid water statistics

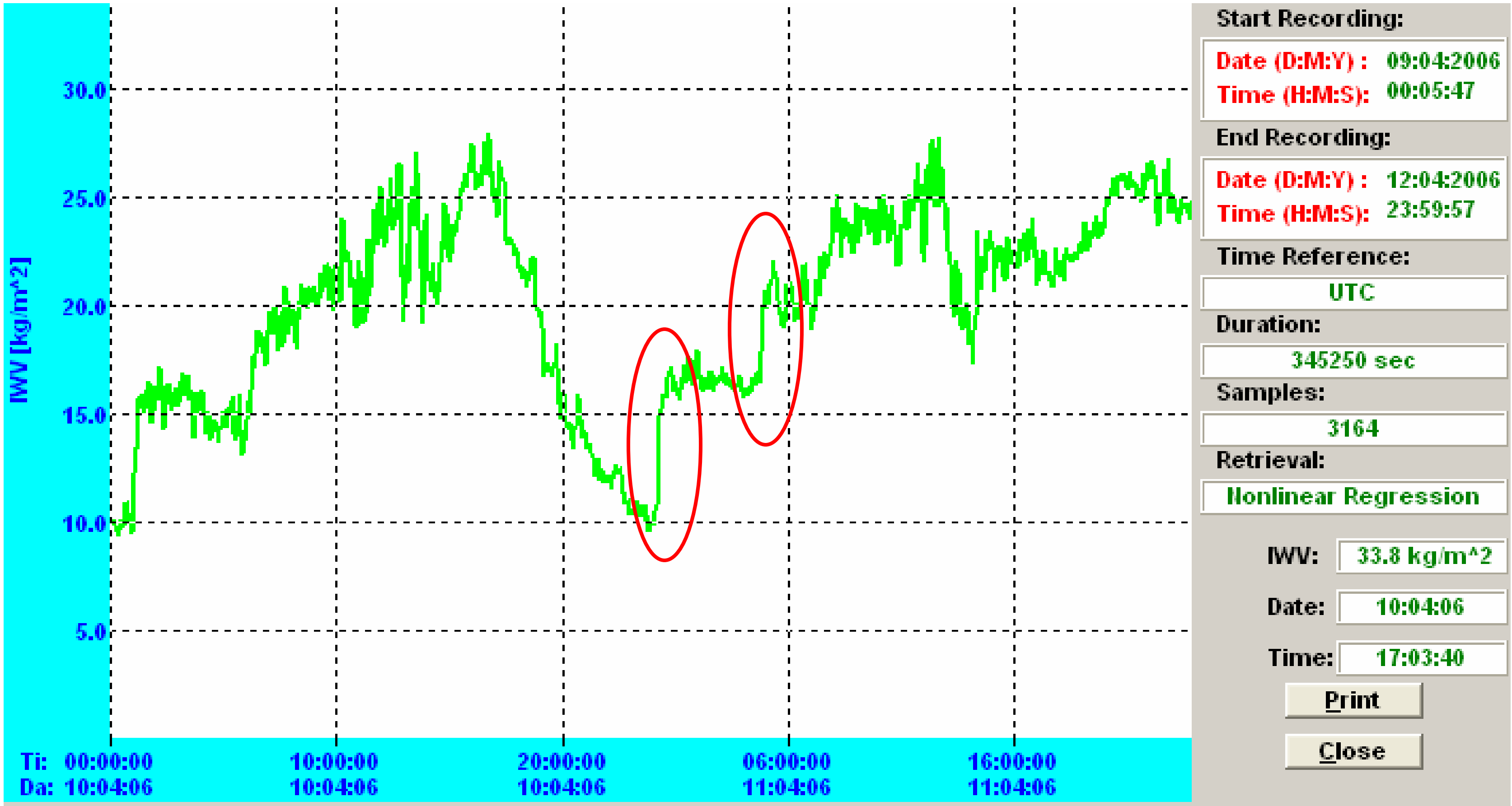
Additional instruments:

Lidar Ceilometer, Micro Rain Radar, Temperature and wind measurements, X-Band-Radar, VHF profiler, UHF profiler, Radiosounding network

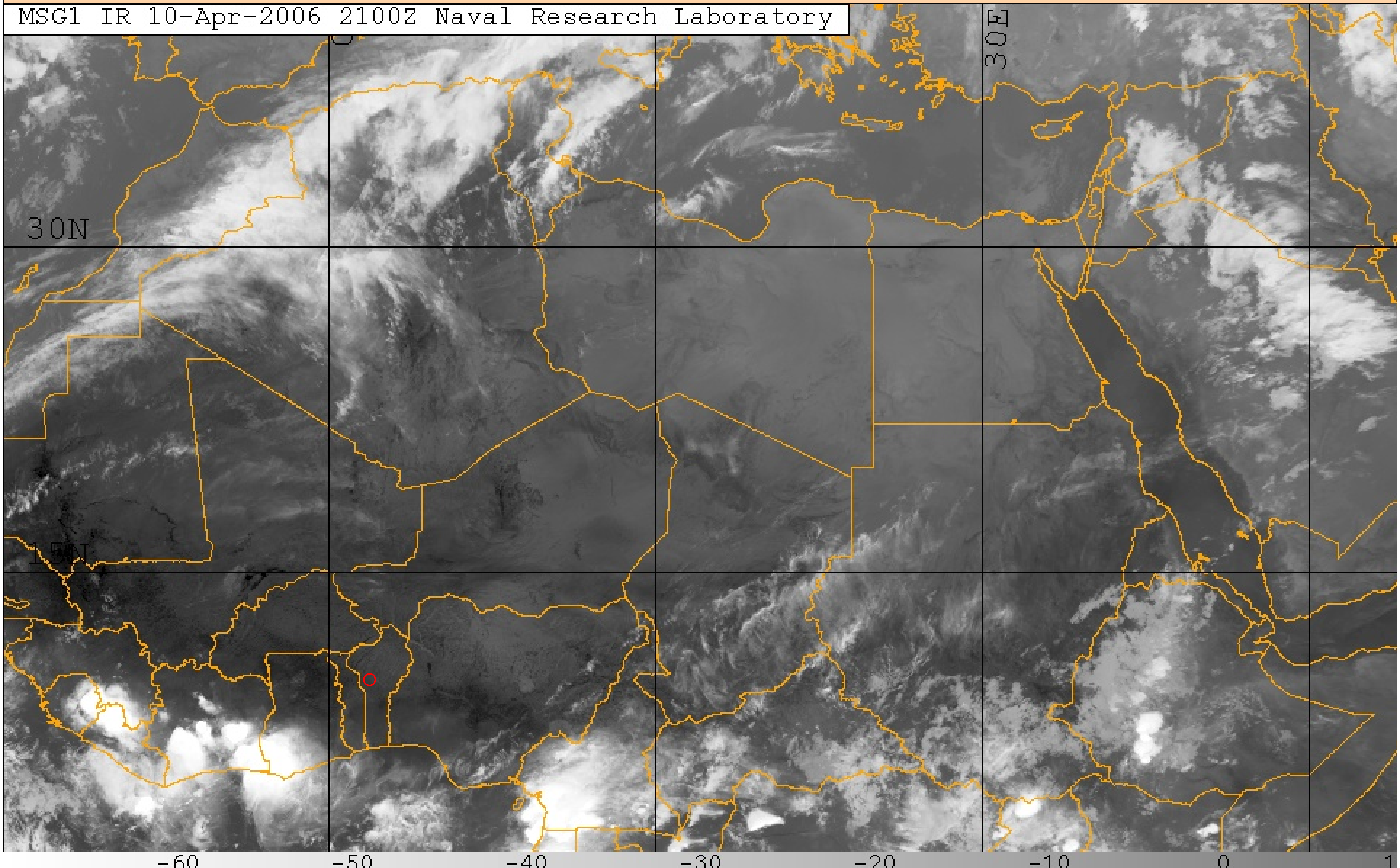
Case study 10/11 April 2006, Nangatchori Benin



IWV (water vapor content) time series

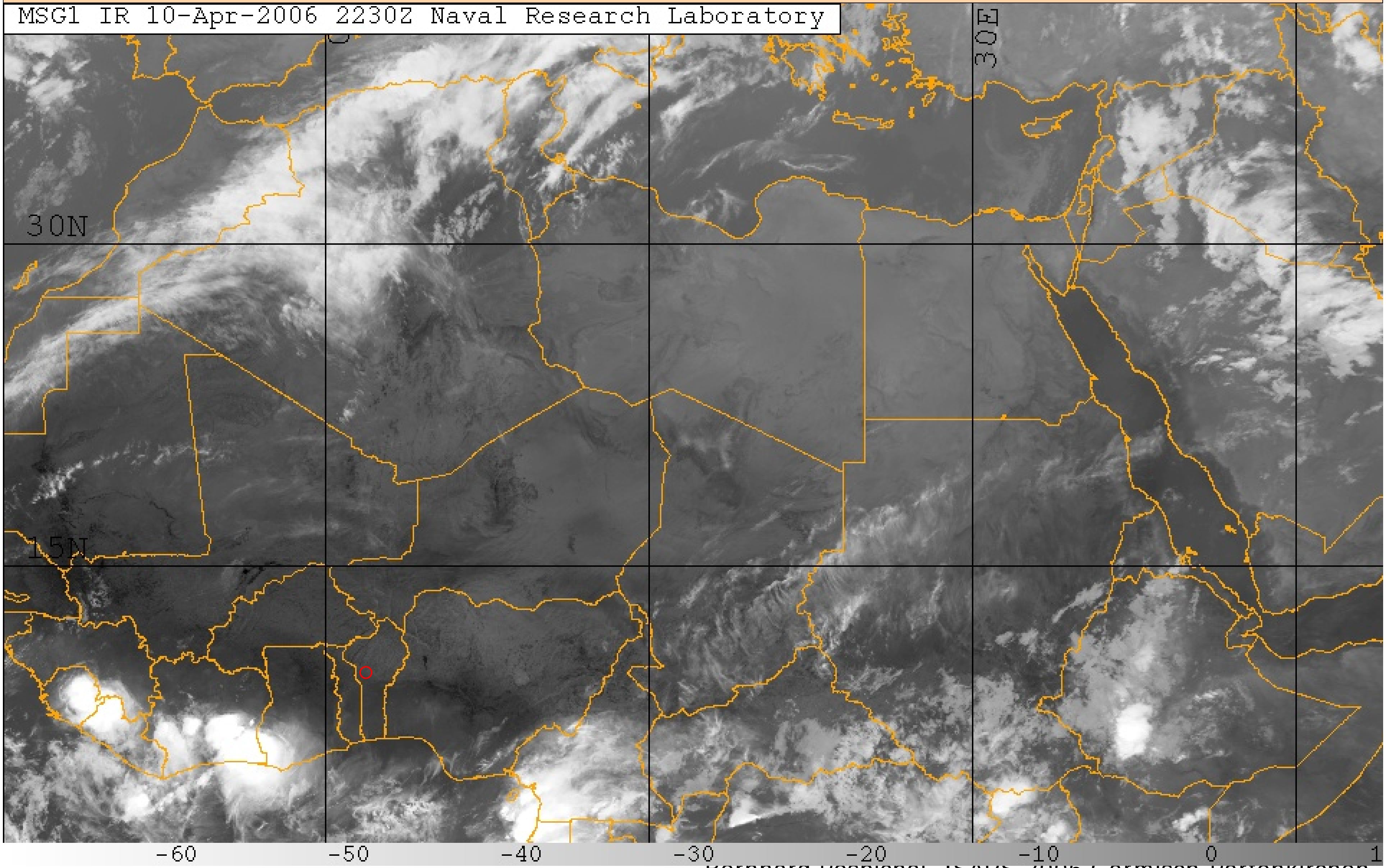


AMMA - African Monsoon Multidisciplinary Analysis



Boundary layer temperature profile measurements using ground-based microwave radiometers

AMMA - African Monsoon Multidisciplinary Analysis



Boundary layer temperature profile measurements using ground-based microwave radiometers

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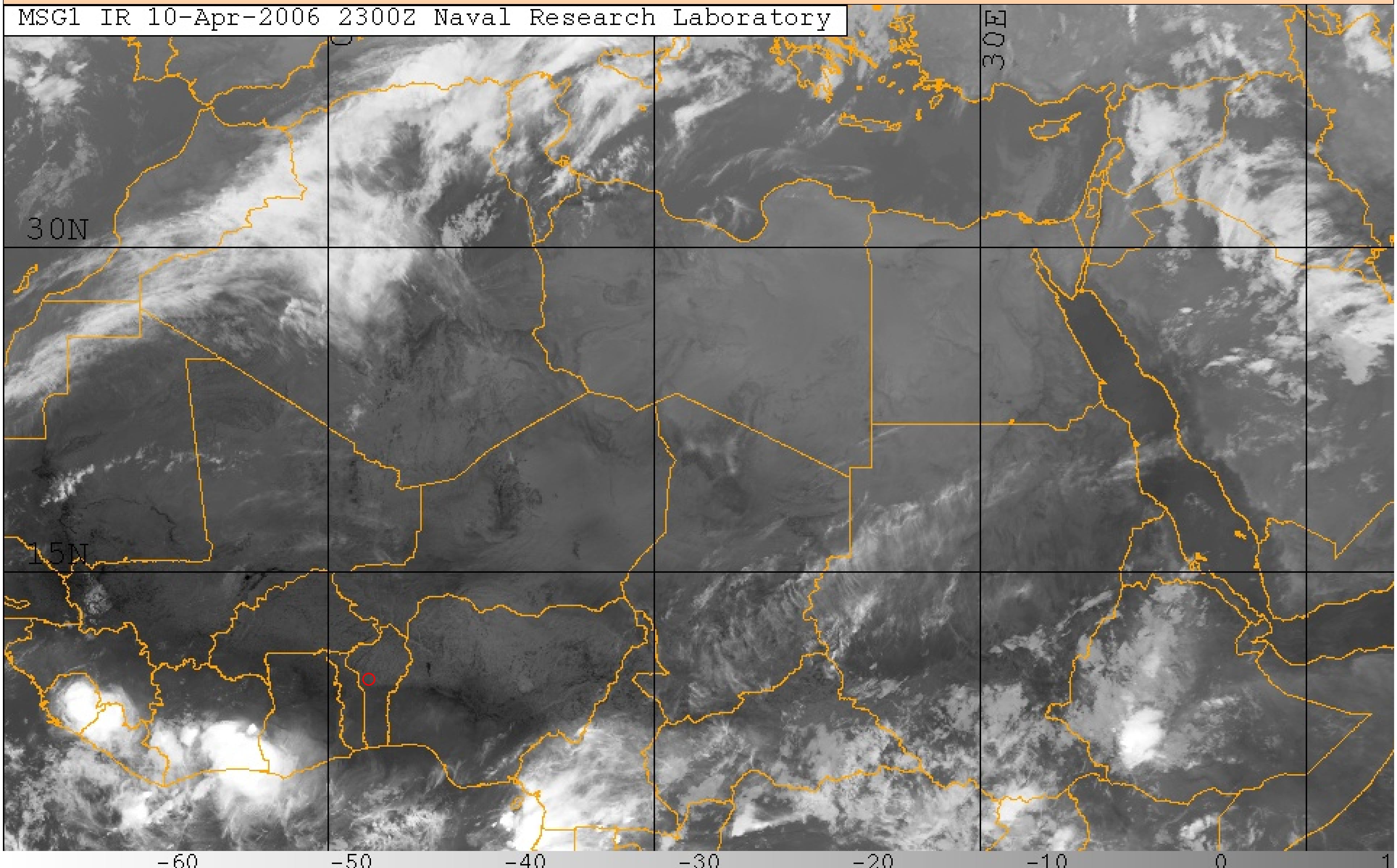

Boundary layer temperature profile measurements using ground-based microwave radiometers

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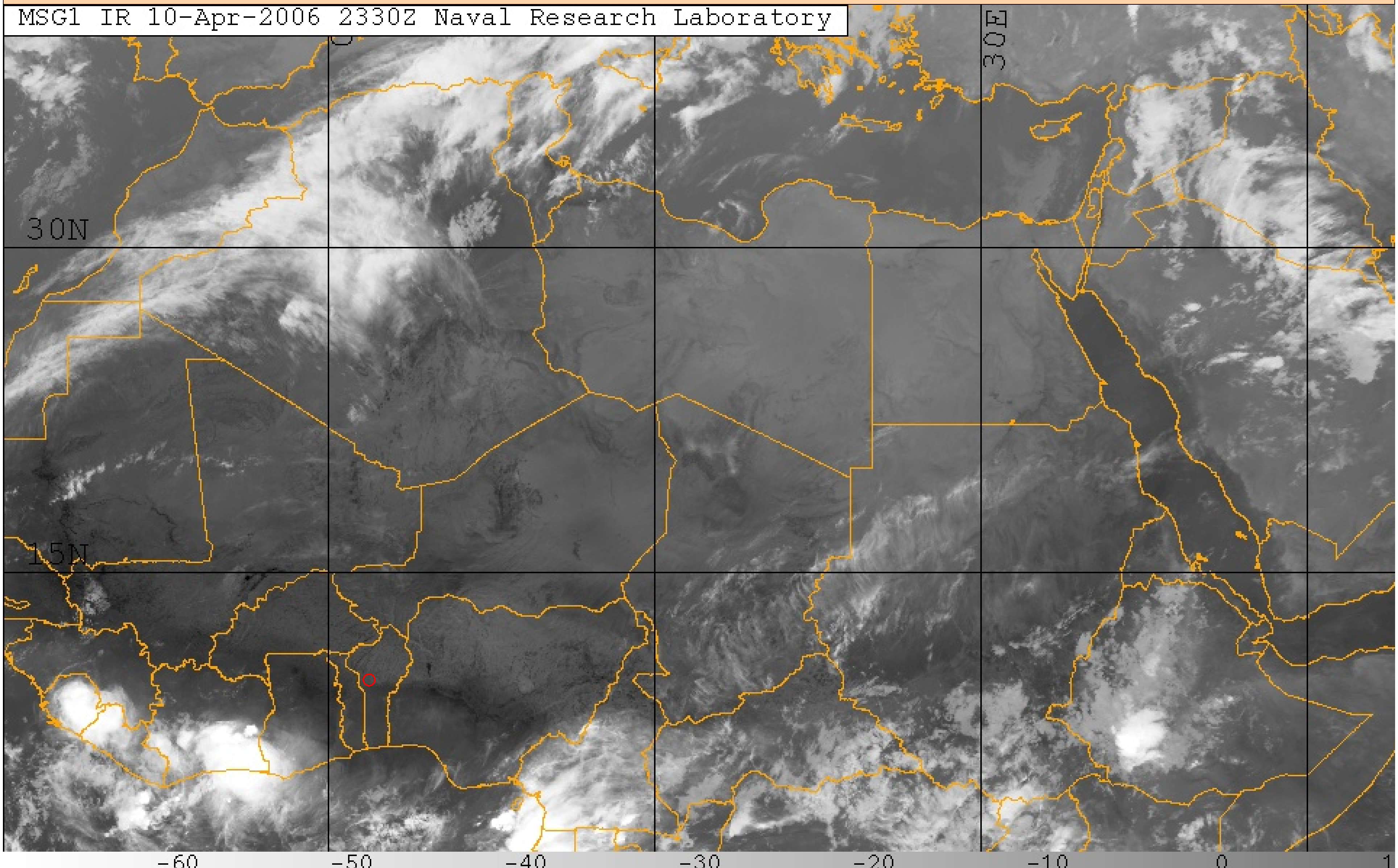

Bernhard Pospichal, ISARS 2006 Garmisch-Partenkirchen

Boundary layer temperature profile measurements using ground-based microwave radiometers

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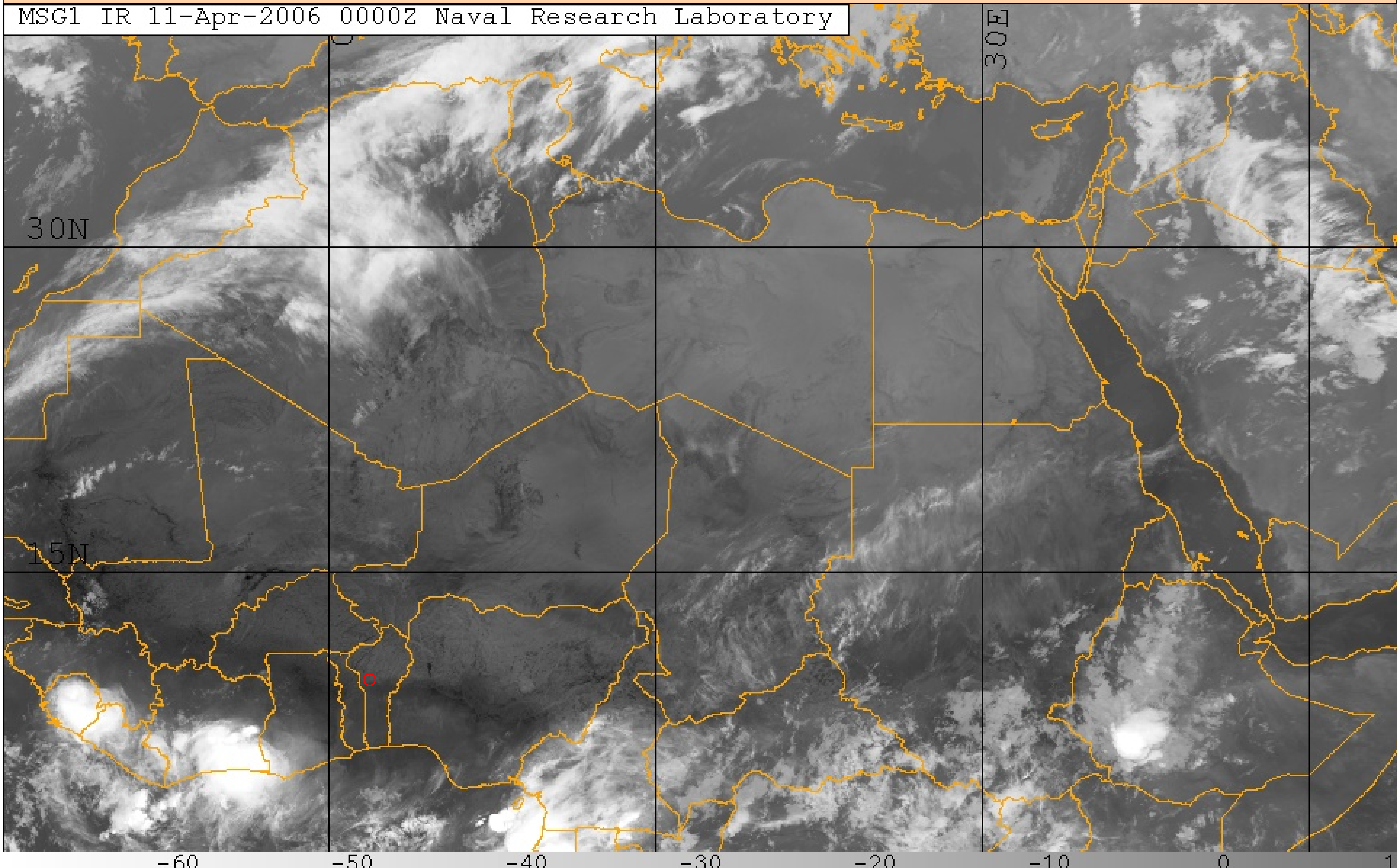

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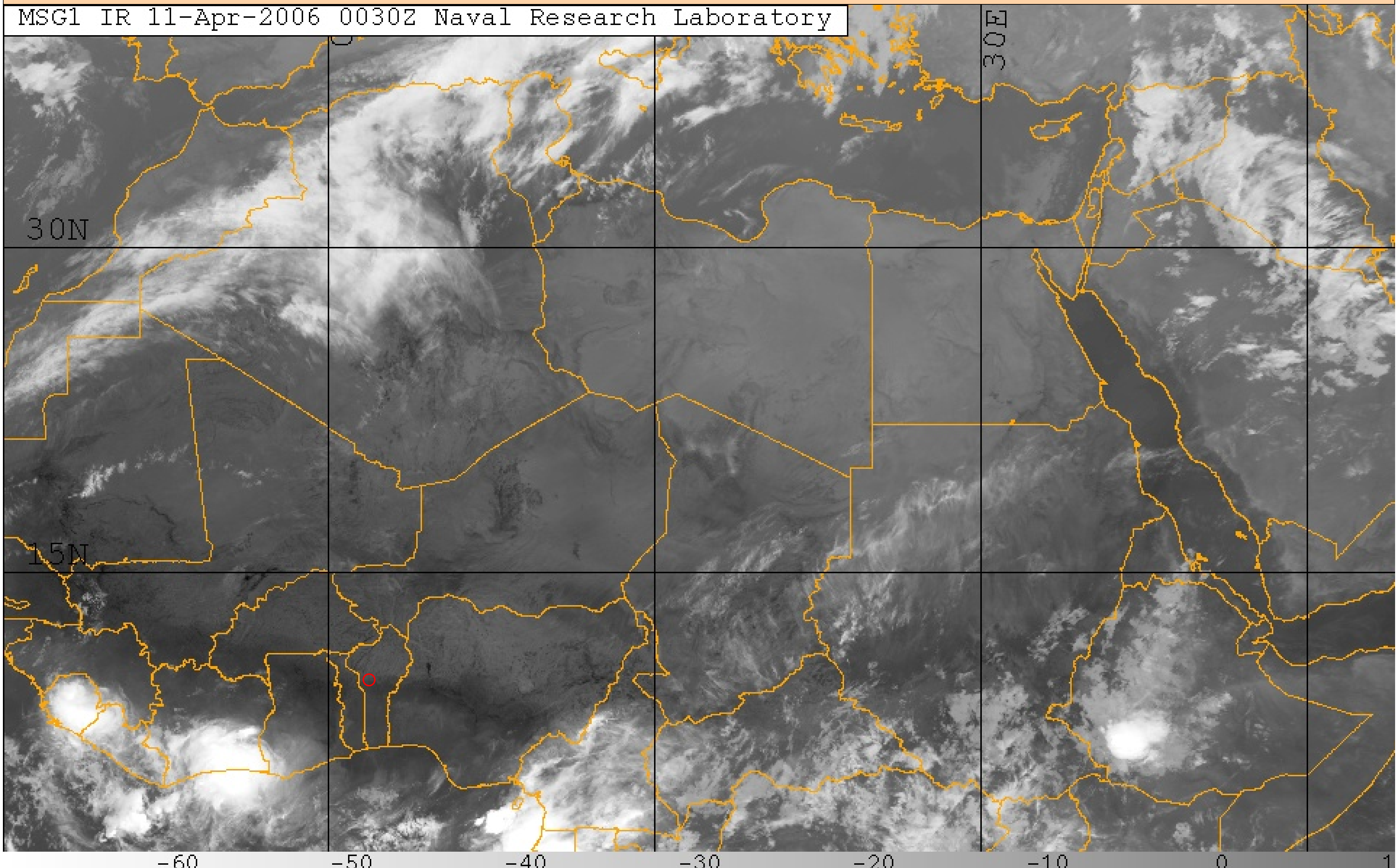
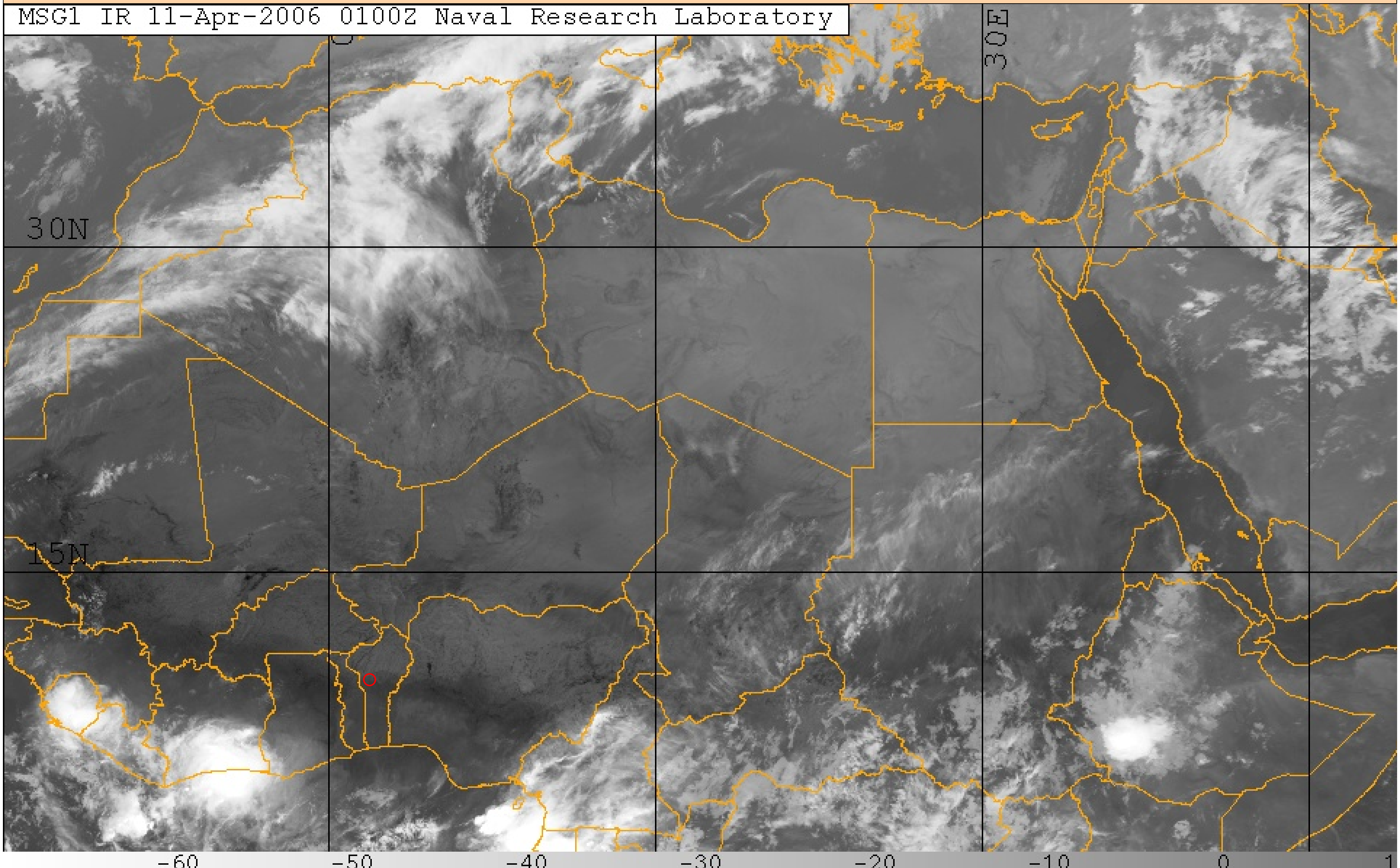


Boundary layer temperature profile measurements using ground-based microwave radiometers

AMMA - African Monsoon Multidisciplinary Analysis



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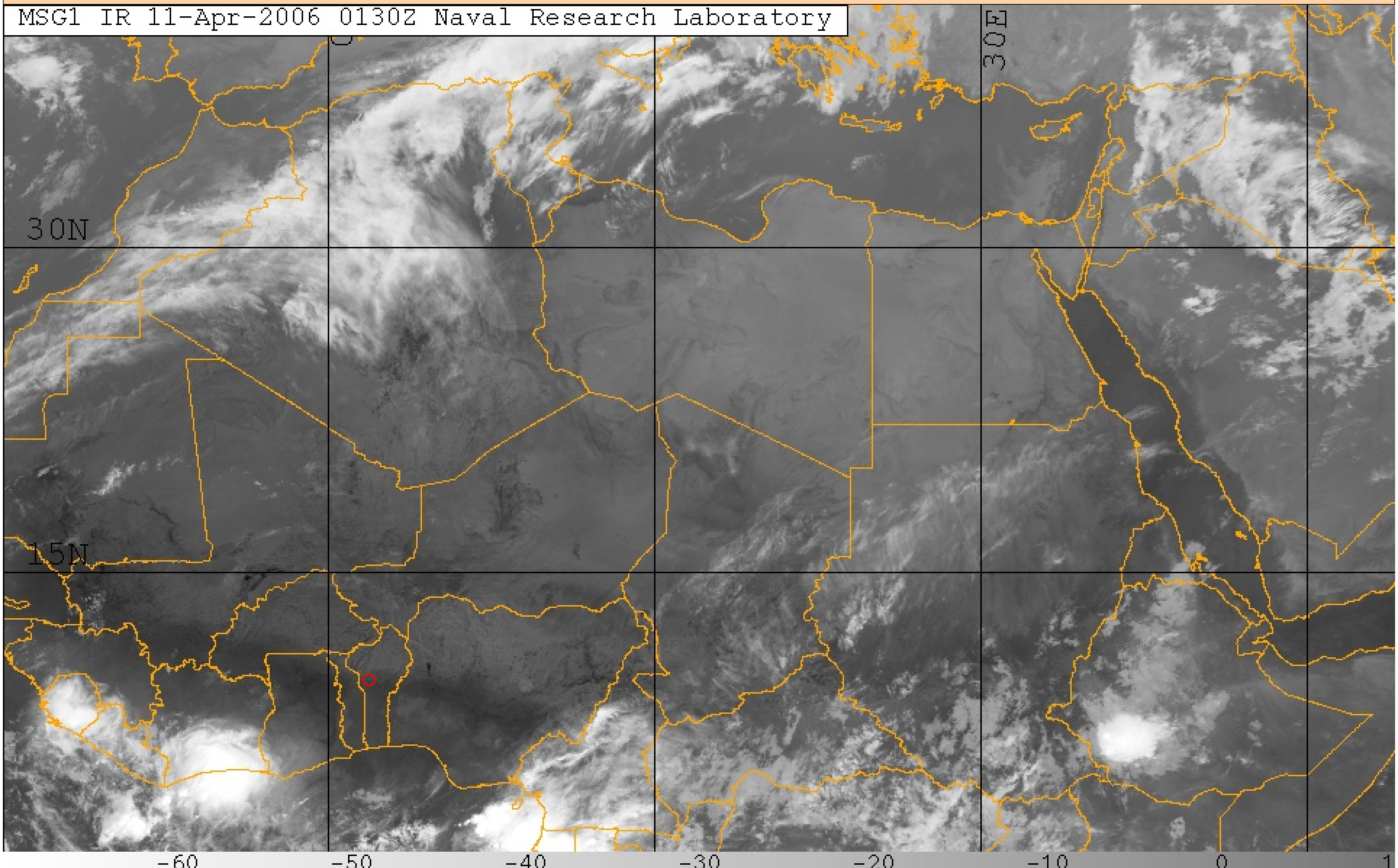

Boundary layer temperature profile measurements using ground-based microwave radiometers

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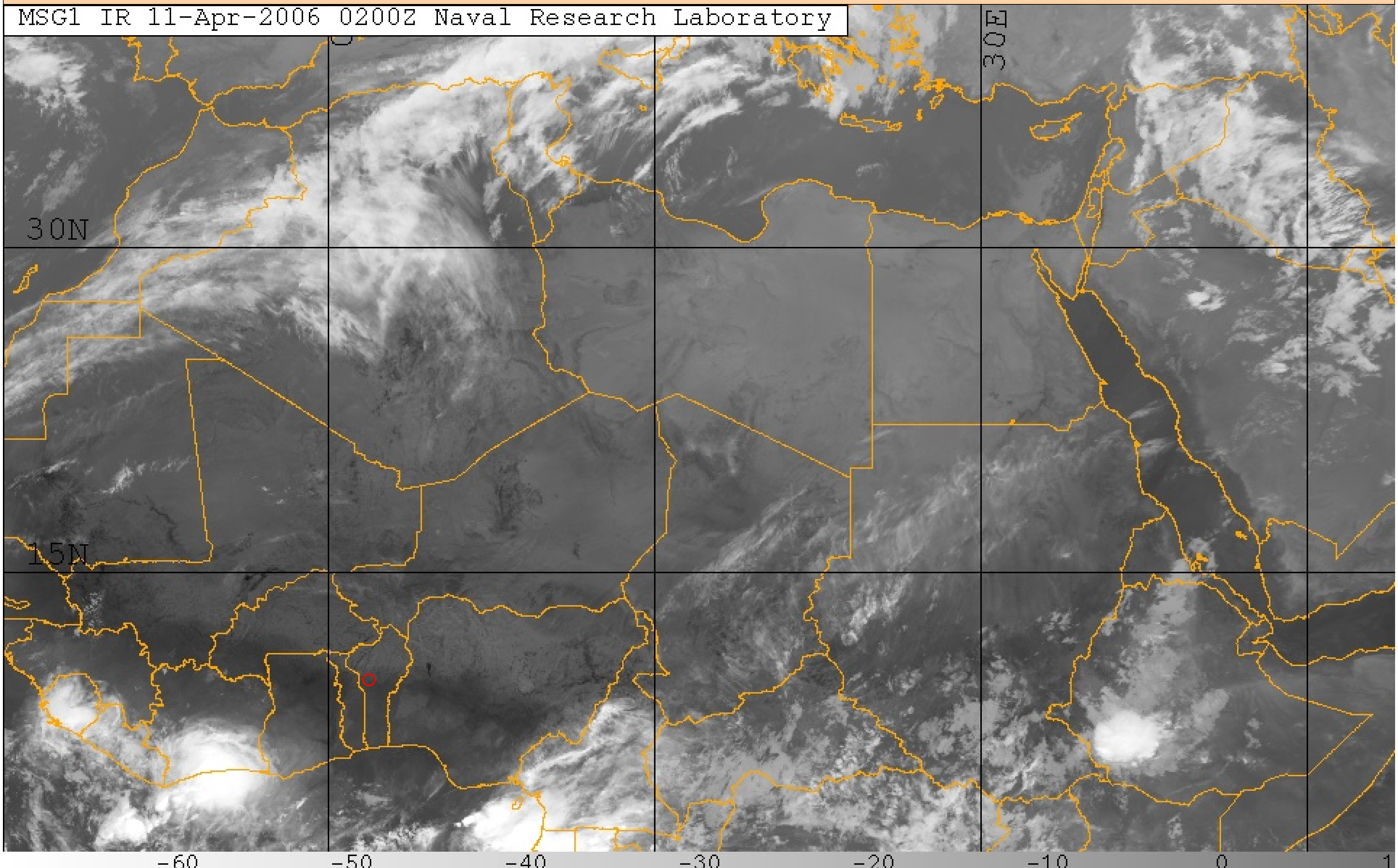

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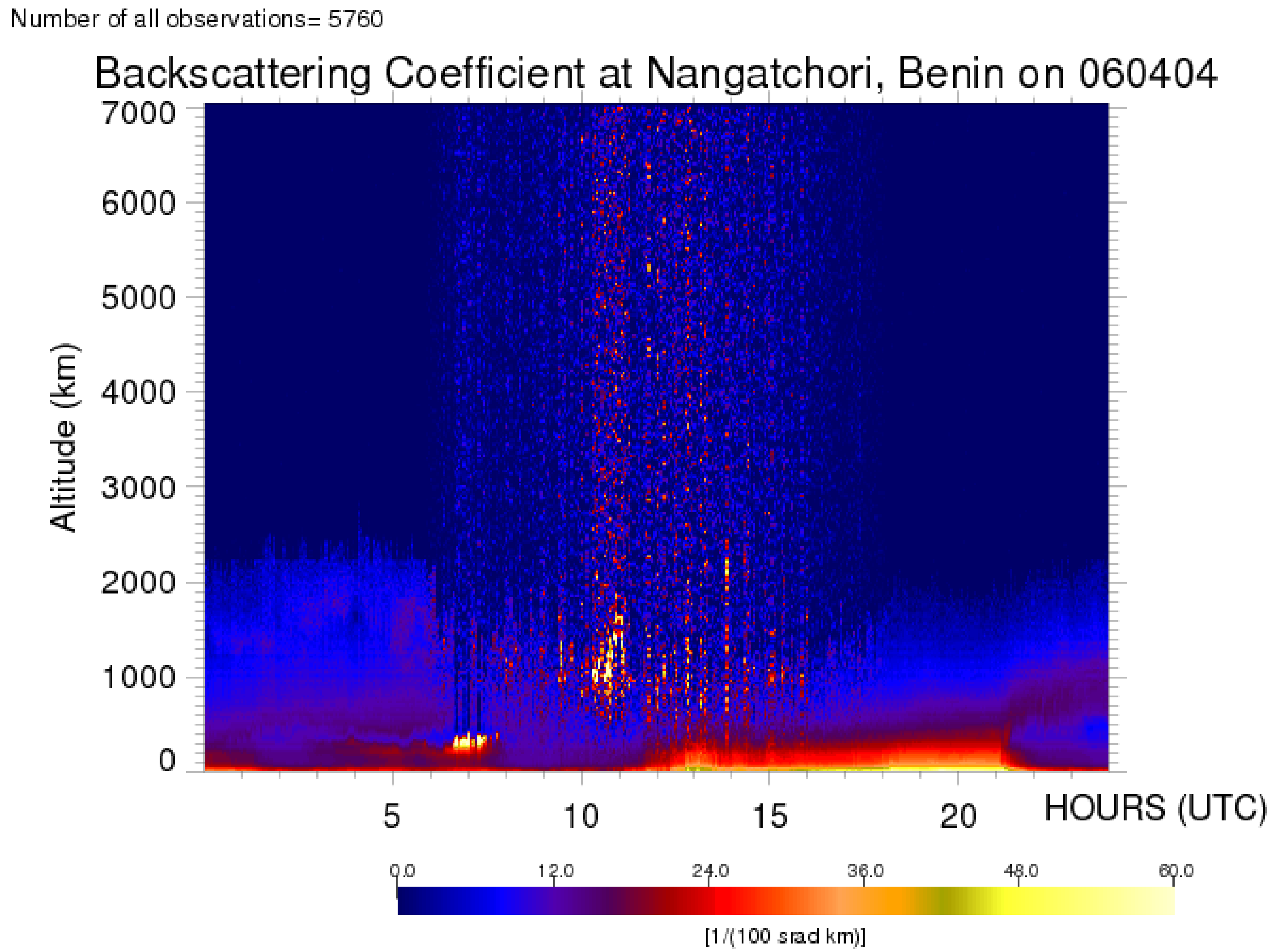

Lidar ceilometer (Vaisala CT25K), 4 April 2006

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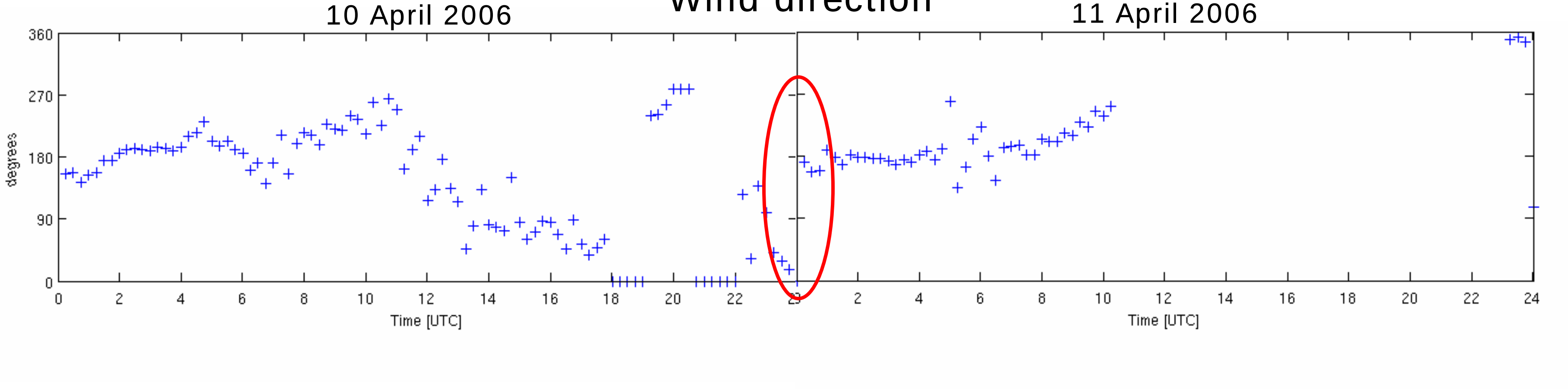
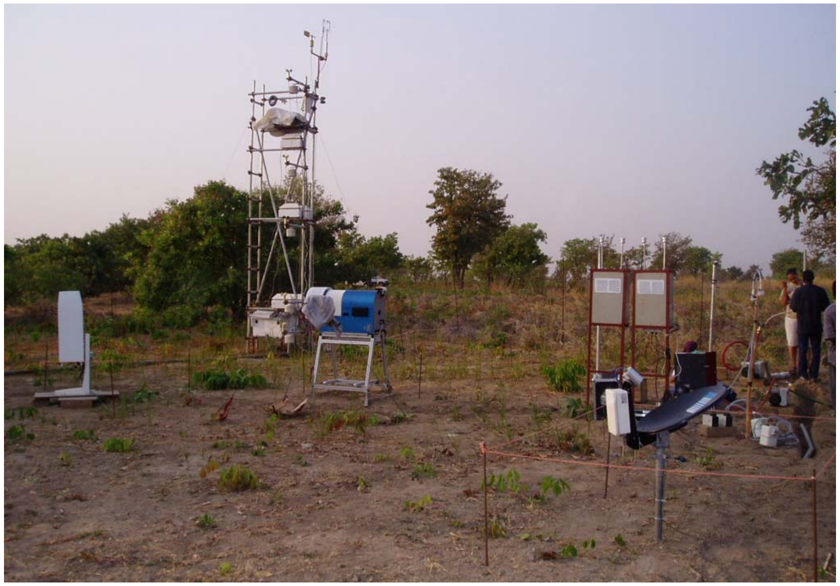
Wind direction



Features:

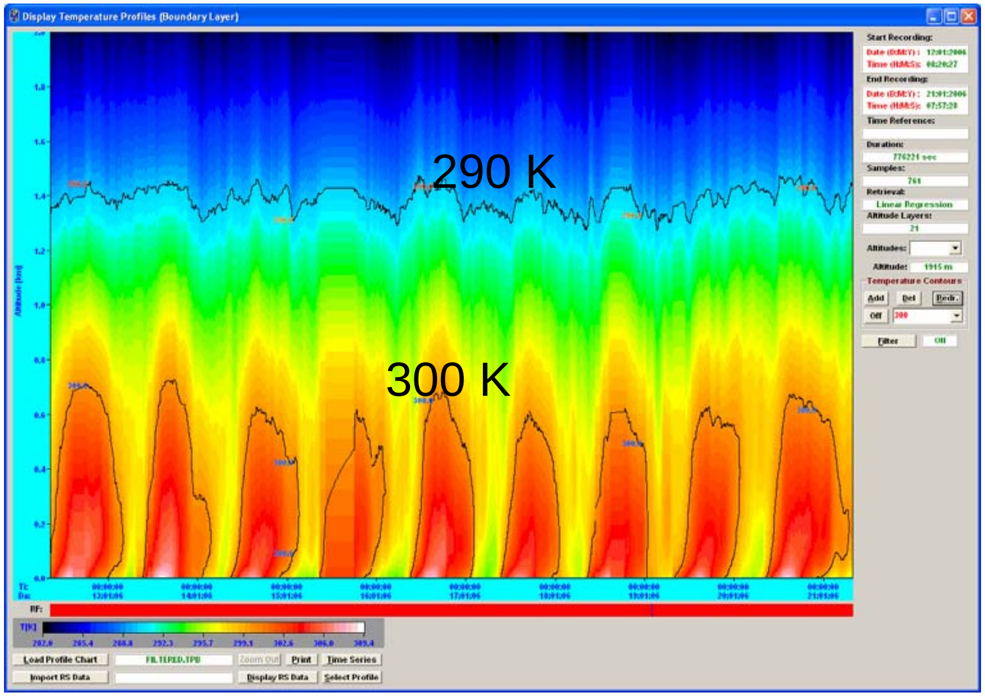
- Distinct jumps in wind direction to south at midnight (often observed)
- Advection of moister and more stable air masses
- Shallow temperature inversion is eroded
- Explanation – gravity current moving north evoked by sea breeze at the coast around sunset (some questions remain due to sparse data)
- No clouds during whole event!

Impressions from Nangatchori



Conclusions and outlook

- Ground-based microwave radiometers can provide valuable information of temperature and humidity profiles in very different climate conditions during clear and cloudy conditions with good accuracy
- **Angular scans** improve the performance of the lowest 1.5 km significantly
- Future: Exploit **synergy** with other remote sensing systems (temperature lidar, wind profiler, sodar, etc.) for more complete description of the atmospheric state



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Thank you for your attention!