The vertical turbulent structure of the Arctic summer boundary layer during ASCOS

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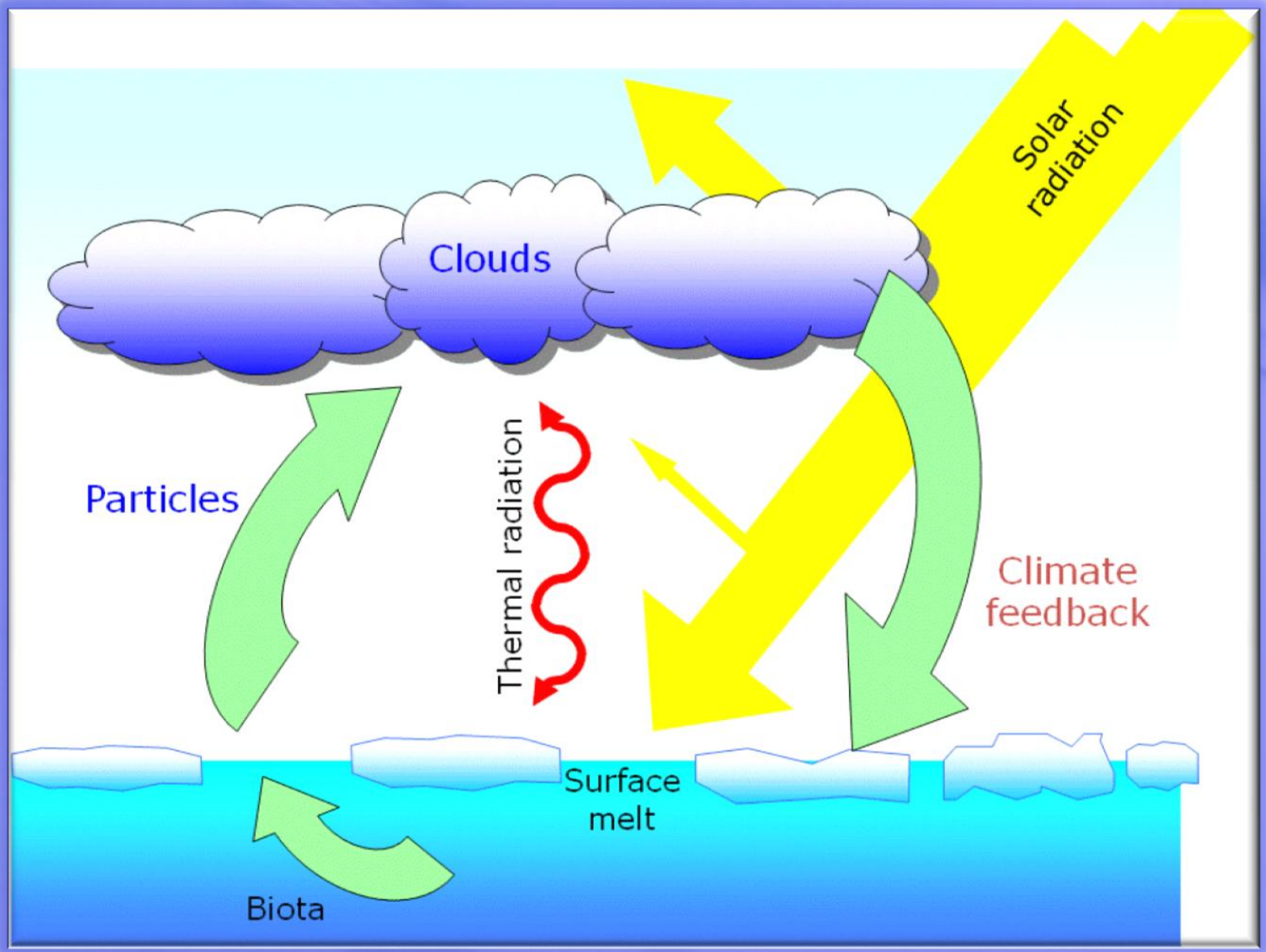
Context: ASCOS (Arctic Summer Cloud-Ocean Study)



- In climate models, **clouds and aerosols** remain the single largest source of uncertainty
- In the Arctic, **clouds** are the single-most important factor in controlling the surface energy balance, and thereby the melt and freeze of ice
- The interplay between processes controlling clouds in the Arctic are poorly understood
- **ASCOS** studies these processes in detail

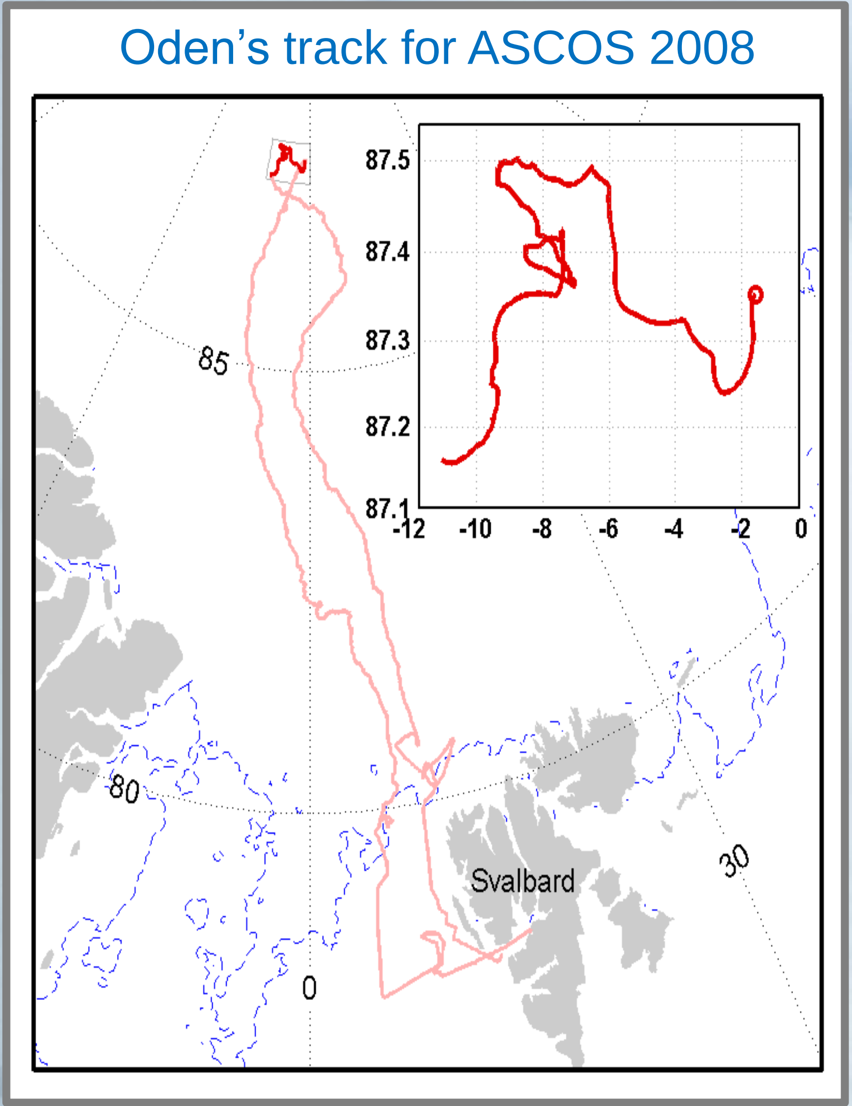
Context: ASCOS (Arctic Summer Cloud-Ocean Study)

Arctic Boundary Layer:

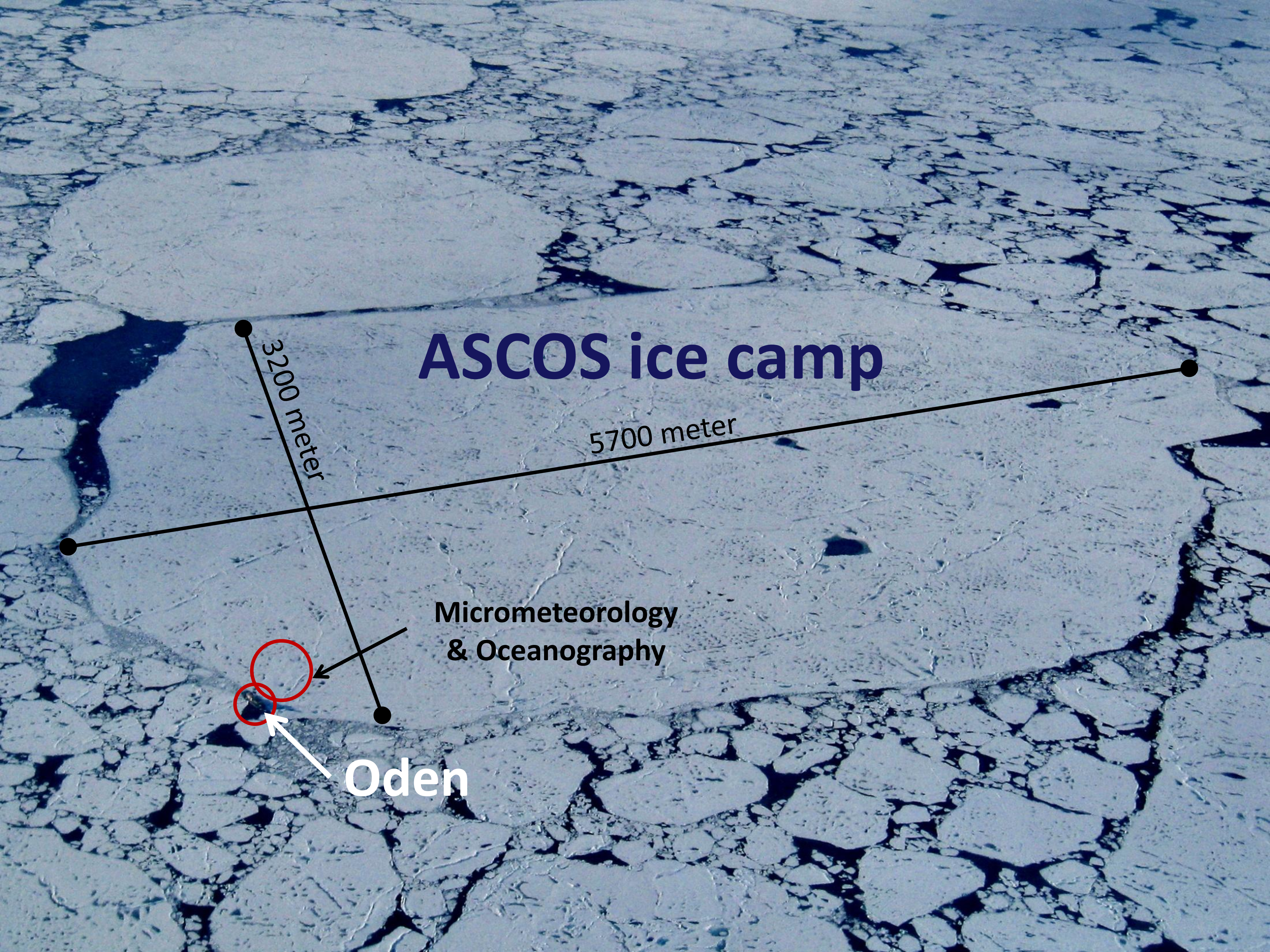
- Role in the interaction between surface (ice/snow) and low-level cloud
- Study the vertical structure with mean and turbulent properties

1. ASCOS experiment
2. Observations used in this study
3. The Boundary layer structure
4. Estimation and study of the turbulent processes
5. Conclusion

1. ASCOS Experiment



- Period**: August 12 – Sept 1 2008**
- Location: 87-87.6°N, 1-11°W
- Observations for **a continuous description of the mean thermodynamical PBL structure**


ASCOS ice camp
3200 meter
5700 meter
Micrometeorology
& Oceanography
Oden

2. Observations used in this study

- From the surface

Turbulence and micrometeorology masts (30m)

Two different level @ 30m and @ 15m:
- **Mean met: T, RH, P**
- **Turbulence: u, v, w, T, H**

Tethersonde: turbulent and mean sonde

77 vertical profiles between 0 - 600m:
- **Mean met: T, RH, P**
- **Turbulence: u, v, w, T**

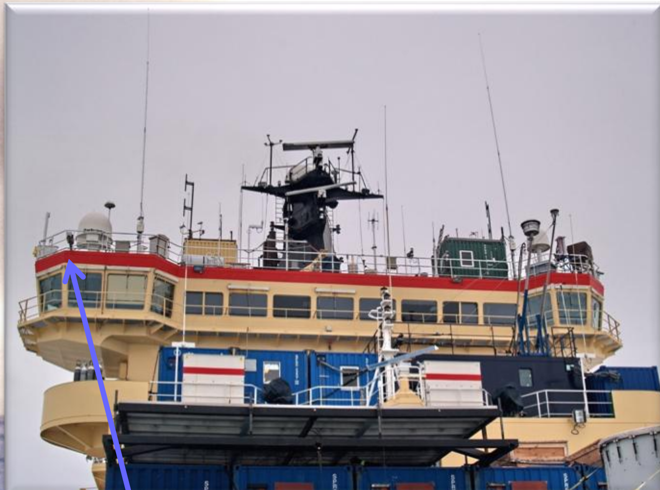
Sodar

- **Vertical profile of u, v, w every 10 min between 0 -500m**

+ 4 radiosoundings per day

2. Observations used in this study

- From the Oden



449 MHz **wind profiler**

- **Vertical profile of u, v, w**

Kband MMCR **cloud radar**

- **Radar reflectivity showing cloud cover**

NOAA **celiometer**

- **Base of the clouds**

60MHz scanning **radiometer**

- **Vertical profile of T**

All the data deduced from these instruments (from ground and from the Oden) have been combined to study the boundary layer structure

3. Boundary-layer structure

- The Richardson number: to study the stability of the different layer

$$Ri_g = \frac{\frac{g}{\theta_v}\frac{\partial \theta_v}{\partial z}}{\left(\frac{\partial u}{\partial z}\right)^2 + \left(\frac{\partial v}{\partial z}\right)^2}$$

$$\frac{\text{Turbulence by } \textbf{BUOYANCY}}{\text{Turbulence by } \textbf{SHEAR}}$$

$Ri_g > 1$ → **stable**

$Ri_g < 0$ → **unstable**

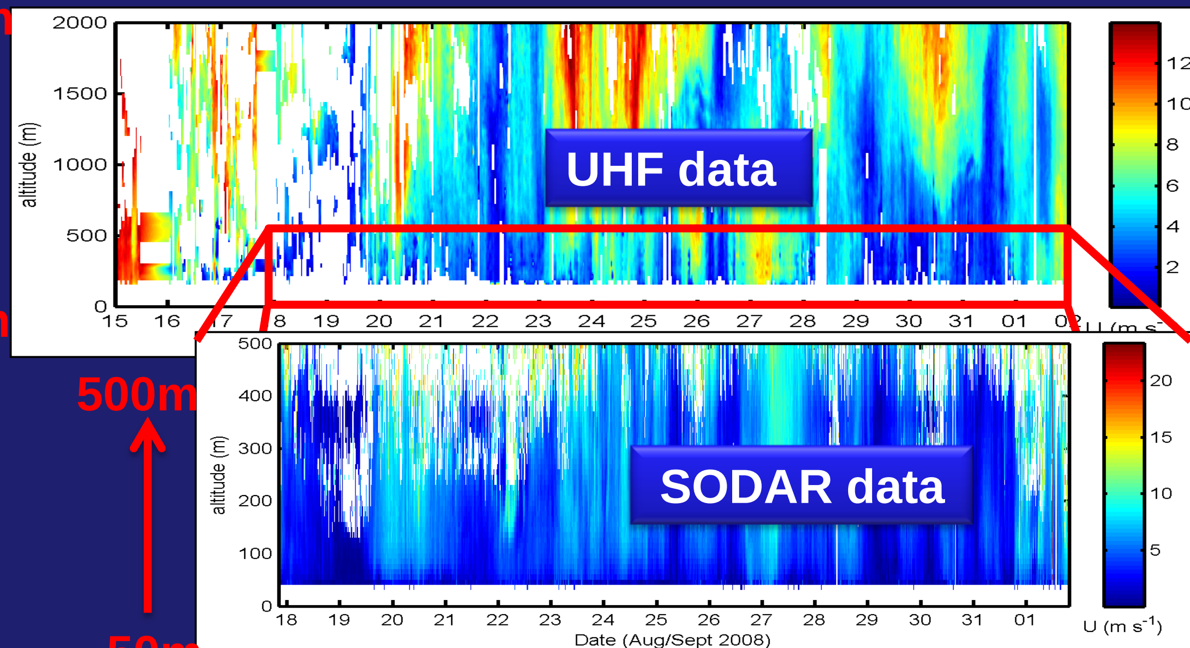
- U, V : obtained with a combination between **UHF** and **Sodar**

2000m

200m

500m

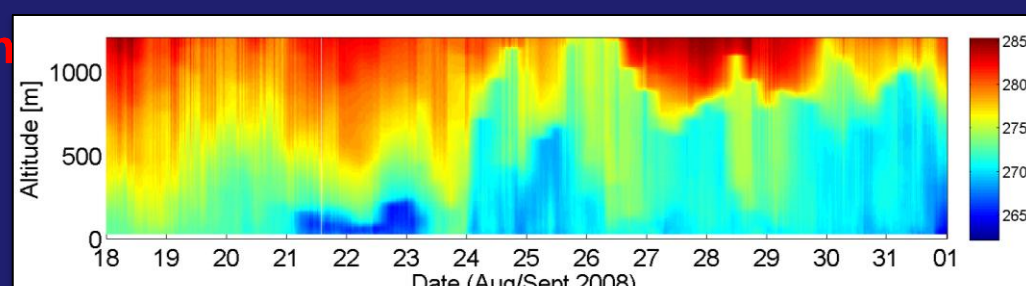
50m



- Θ : obtained with the 60 GHz scanning microwave **radiometer**

1200m

20m



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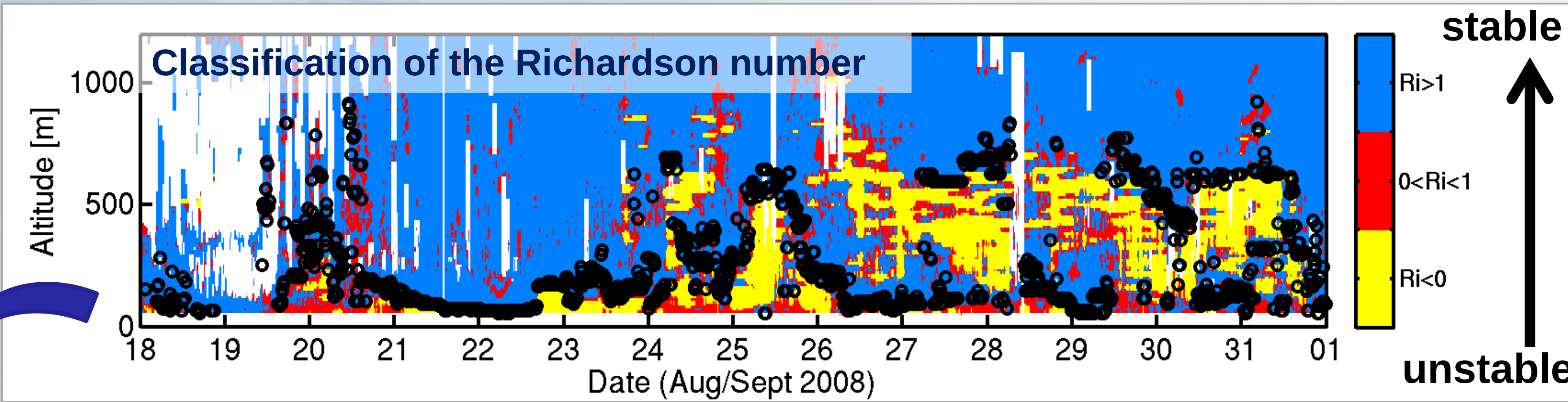
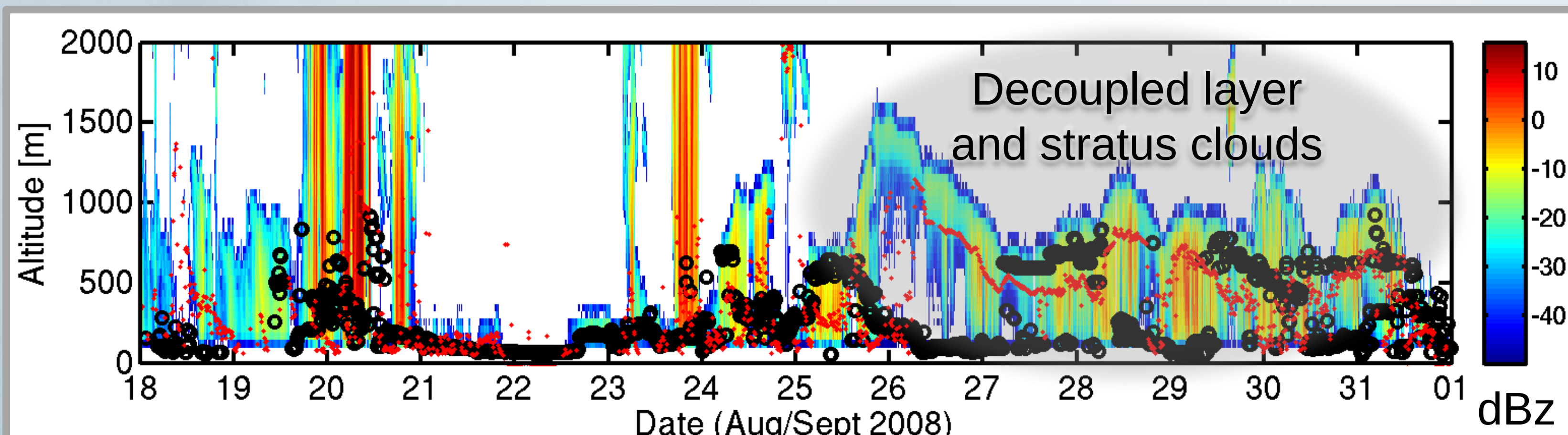


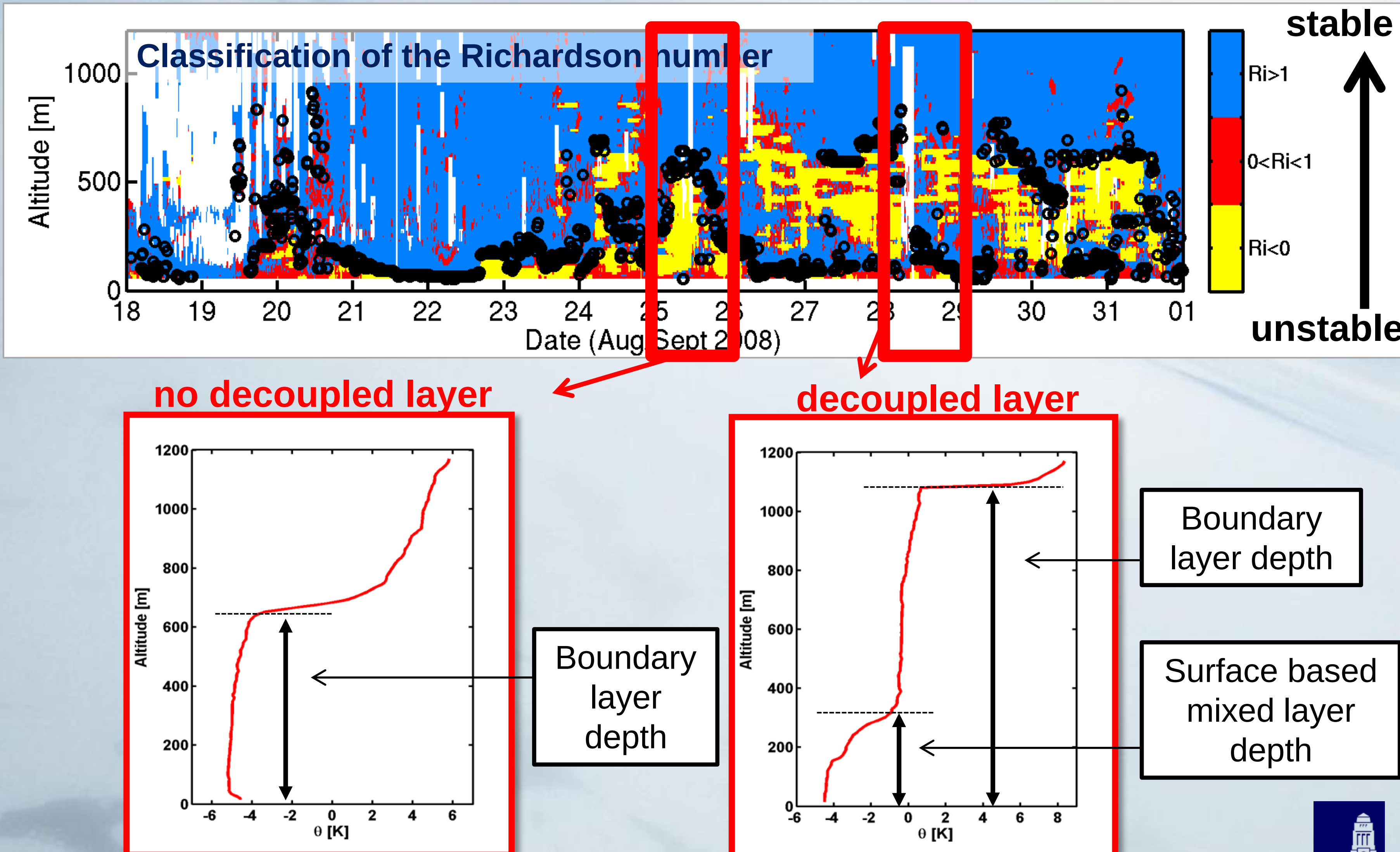
Estimation of the top of boundary layer ⇨ **interface between unstable and stable layer**



Radar reflectivity showing cloud cover

3. Boundary-layer structure

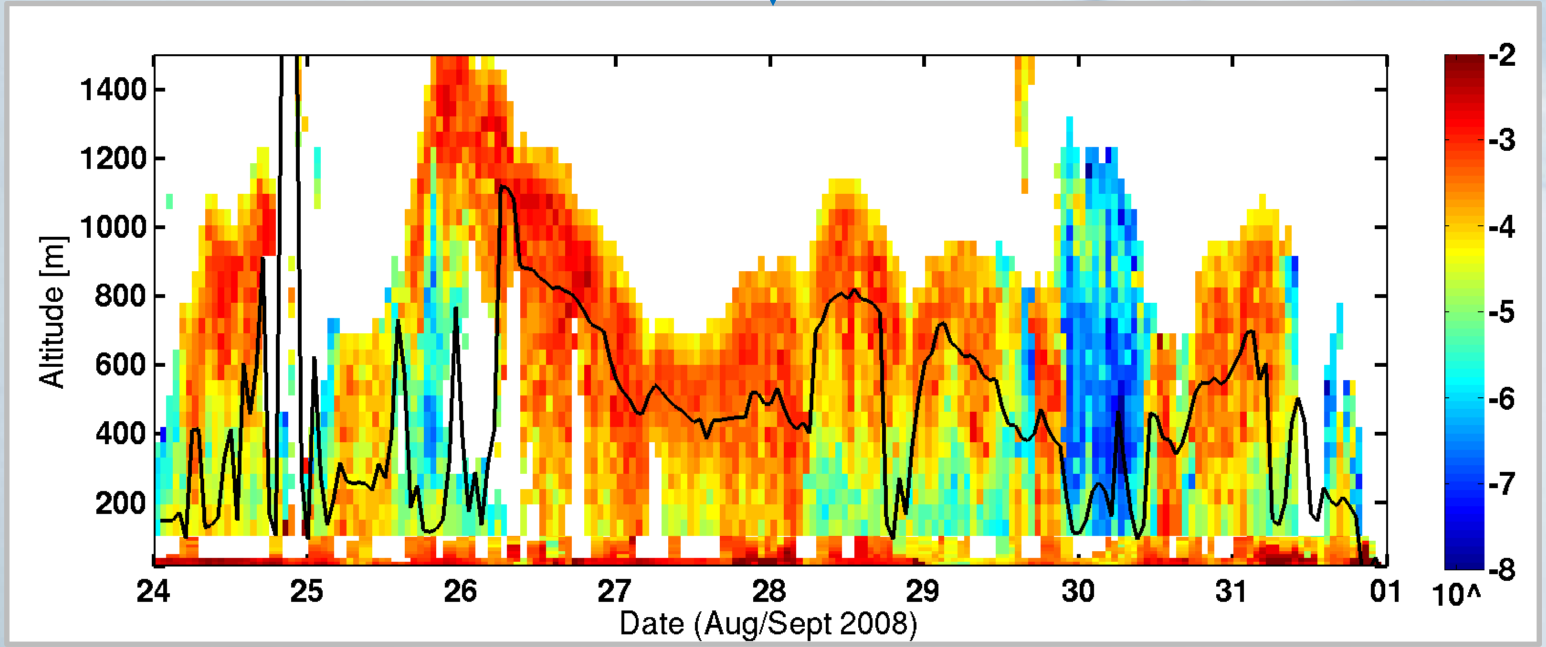
- The Richardson number: to study the stability of the different layer



4. Estimation of the turbulent processes

- The turbulent dissipation rate (Ɛ) :
  - ✓ is a term of the tke Budget
  - ✓ to quantify the turbulence

<u>MMCR</u>:
- Continue observations of Ɛ in the Boundary layer
- Data validated with tetherballoon measurements **(Shupe et al. 2012)**



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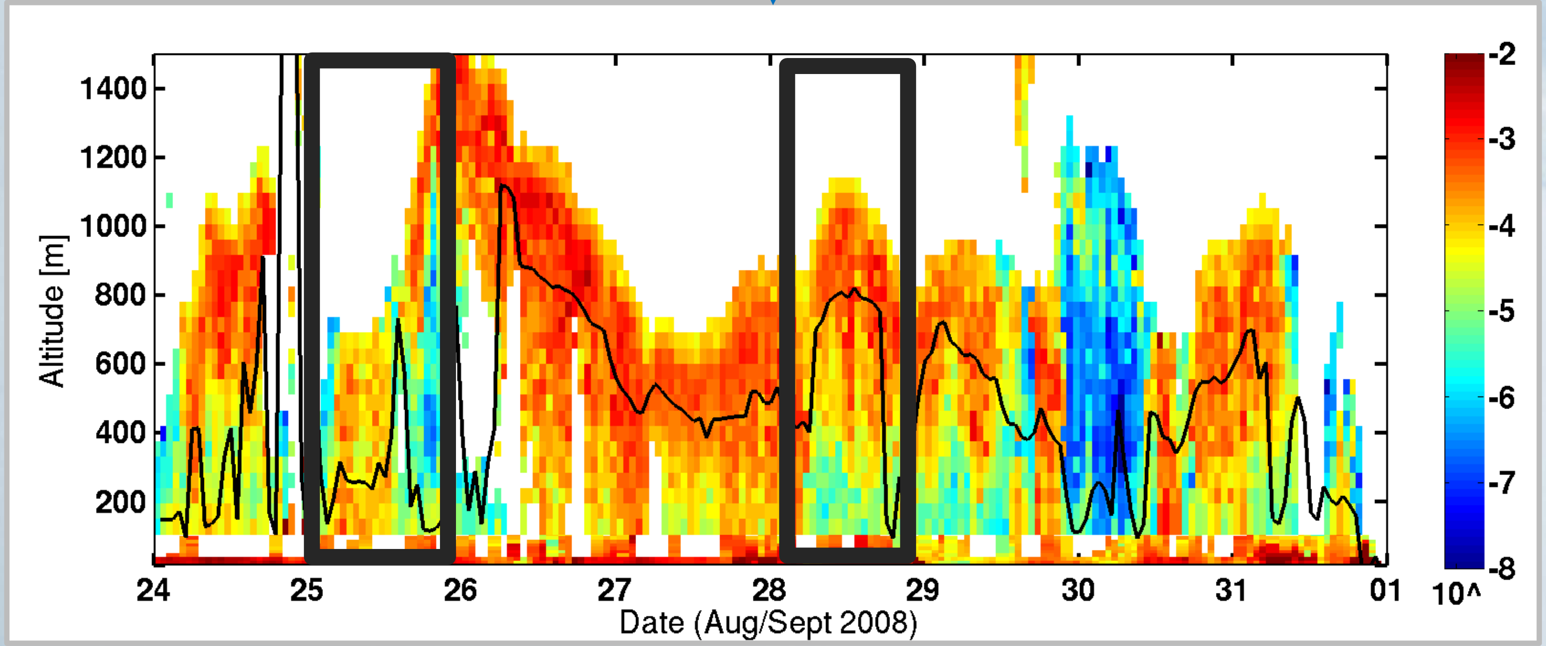
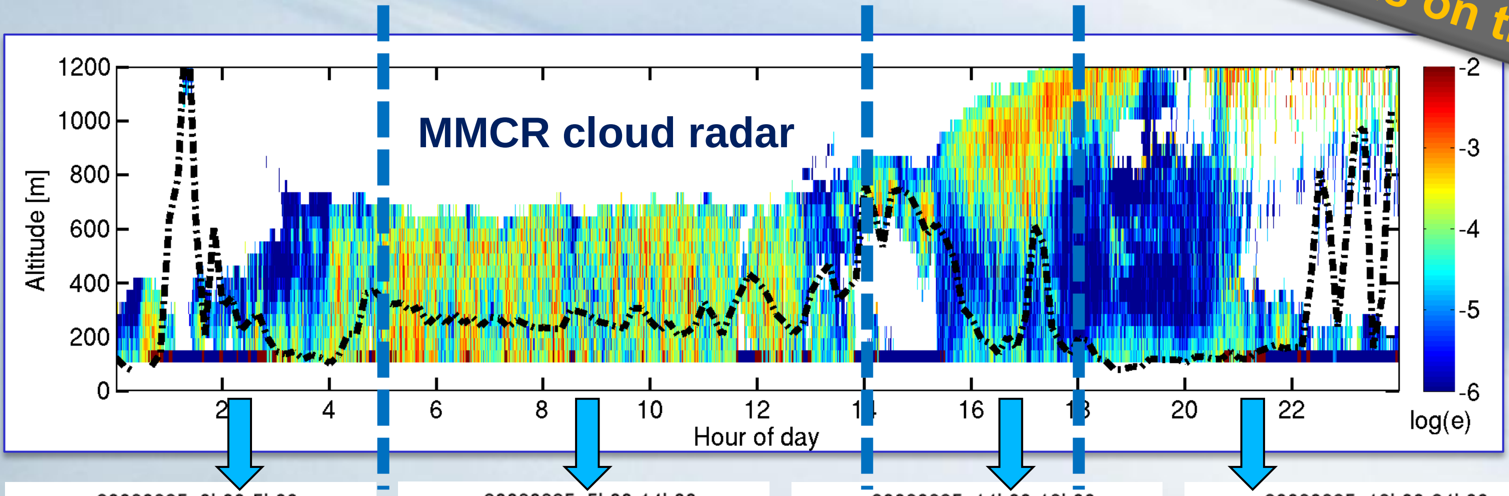
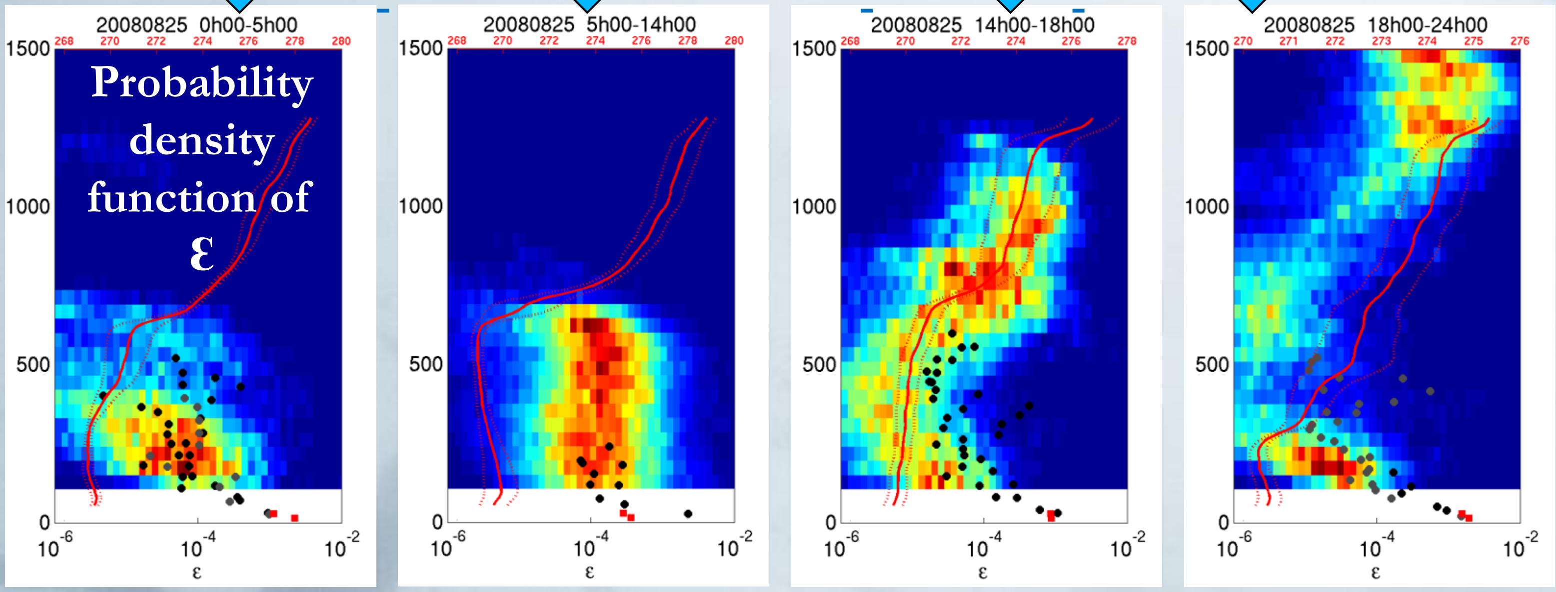


4. Estimation of the turbulent processes

- The turbulent dissipation rate

Focus on the 25 august



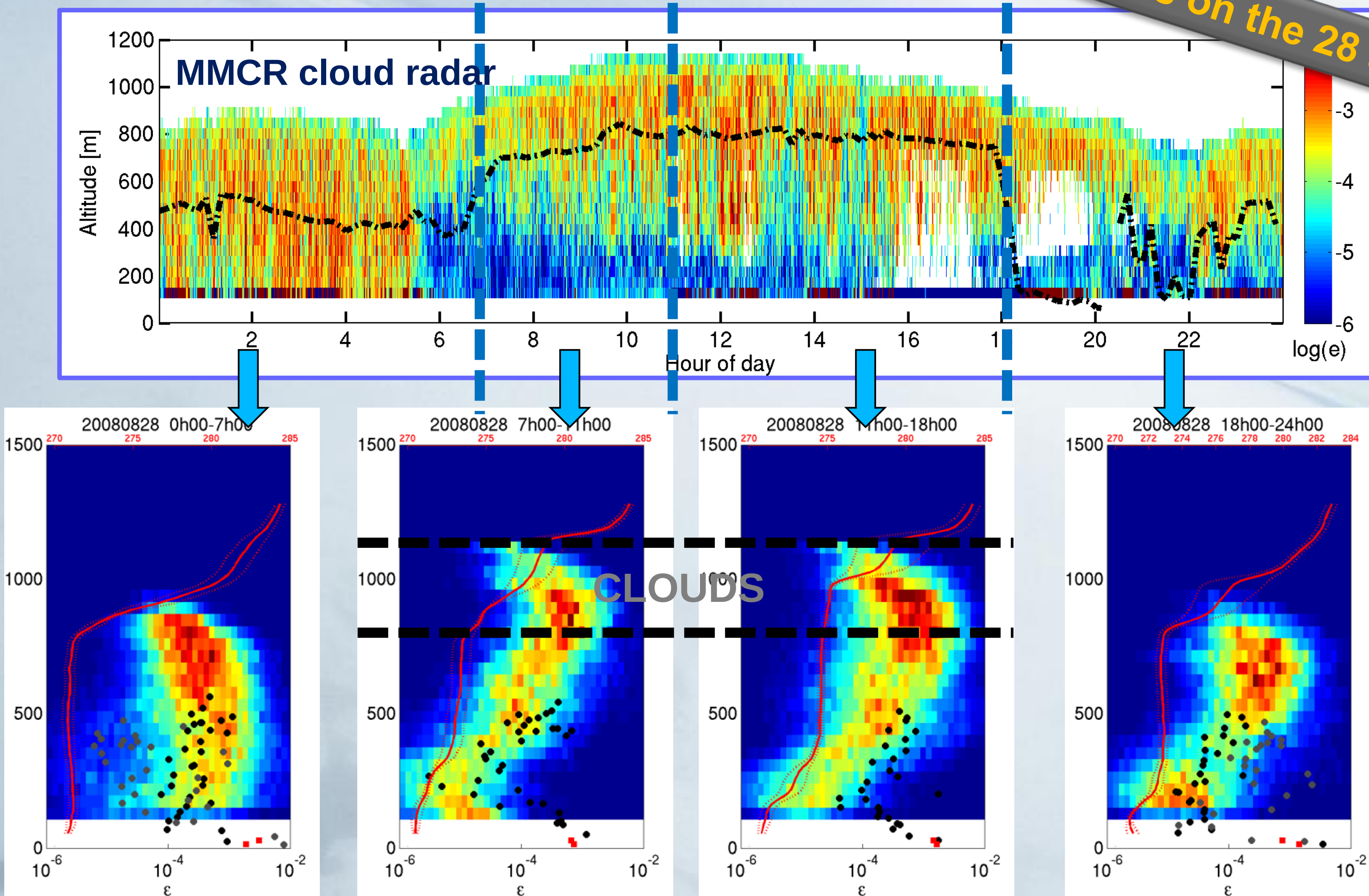


Vertical profile of temperature and ε obtained with MMCR, tethersonde and mast

4. Estimation of the turbulent processes

- The turbulent dissipation rate

Focus on the 28 august



Conclusion

- Innovative combination of multiple remote sensing measurements & retrievals to provide continuous profiles of turbulent mixing indicator (Richardson number)
- Consistent picture from remote sensing (doppler cloud radar) & in-situ measurements (tetherballon)

- Arctic summer (ASCOS) BL often decoupled at ~100m
- Coupling probably dependent on cloud-driven turbulence

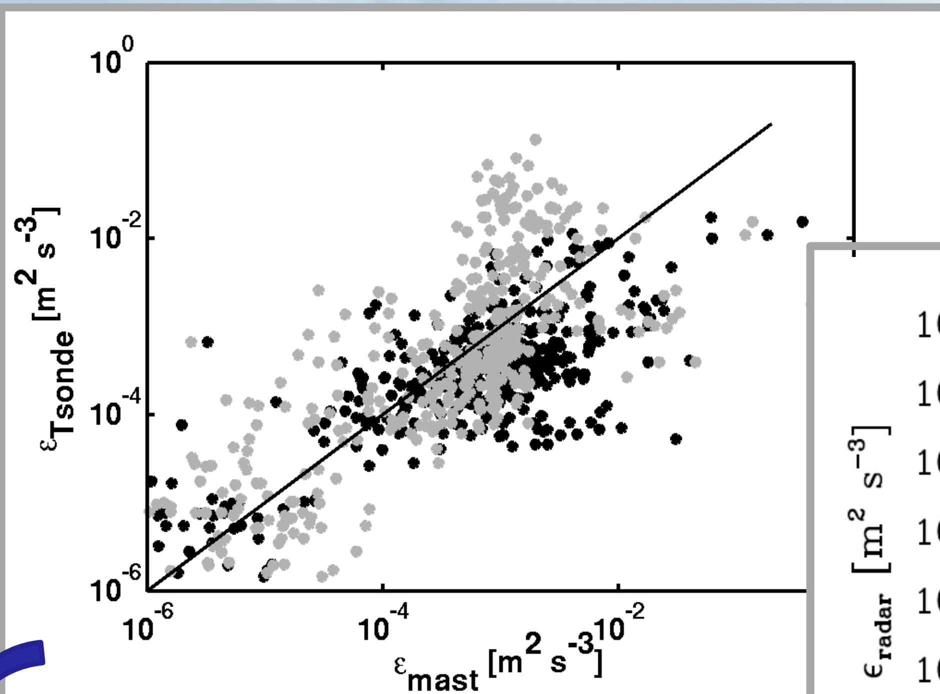
Height of cloud top (BL depth), depth of cloud, depends on synoptic conditions

Merci!

4. Estimation of the turbulent processes

- The turbulent dissipation rate (Ɛ) : - to quantify the turbulence
  - is a term of the **TKE budget**

Comparison: Ɛ obtained **with MMCR radar** and Ɛ obtained **with tethersonde**



Comparison: Ɛ obtained **with the sonic anemometer in the mast** @ 30 m (black dots) and @ 15 m(gray dots) and Ɛ obtained **with tethersonde**

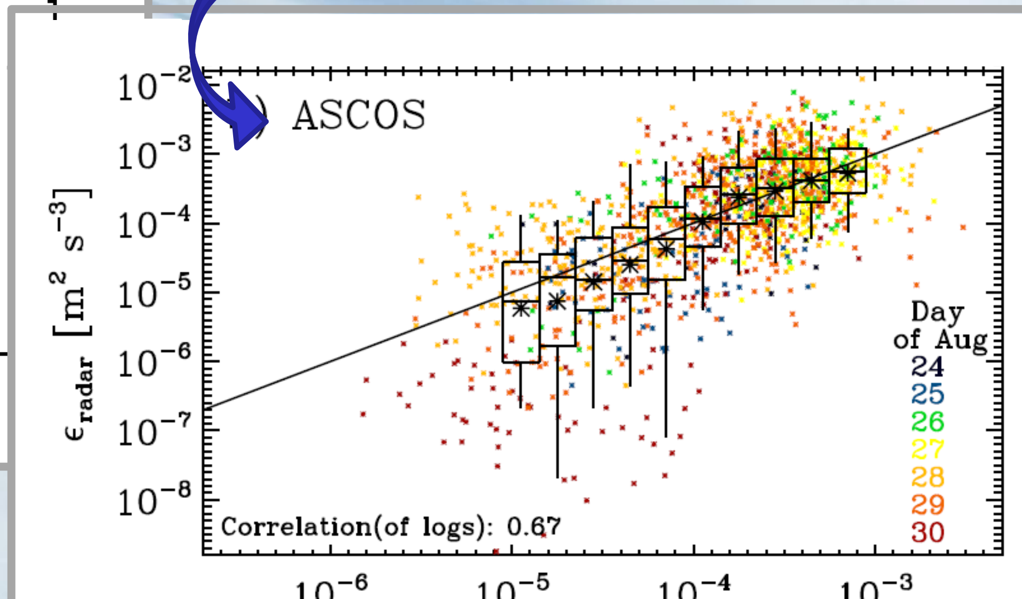


Figure from M. Shupe

Good correlation allow us to have confidence on Ɛ obtained by the MMCR. This instrument permit continue observations of Ɛ in all the boundary layer.