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Experiments in Meteorology and further Developments

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- History
- Scales
- Types of Experiments
- Criticism
- Conclusions
Historical Experiments

Balloon Preußen
Berson and Süring 1901

Kite
Aeronautical Observatory Lindenberg
1905-1940

Typical dimensions:
• 1-D experiment
• Fixed time
Historical Experiments

Balloon Preußen
Berson and Süring 1901

Kite
Aeronautical Observatory Lindenberg
1905-1940

Typical dimensions:
• 1-D experiment
• Fixed time

Excursion to the Lindenberg Meteorological Observatory will take place on Wednesday, 14 September 2011 at 13:30
New Experiments

KANSAS experiment 1968

Typical dimensions:
- 1-D experiment
- continuously (month)

<table>
<thead>
<tr>
<th>experiment</th>
<th>location, time</th>
<th>reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>O’Neill</td>
<td>O’Neill, USA 1953</td>
<td>Lettau (1957)</td>
</tr>
<tr>
<td>Kerang</td>
<td>Kerang, Australien 1962</td>
<td>Swinbank and Dyer (1968)</td>
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<td>Hay</td>
<td>Hay, Australien 1964</td>
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<tr>
<td>Hanford</td>
<td>Hanford, USA 1965</td>
<td>Businger et al. (1969)</td>
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<tr>
<td>Wangara</td>
<td>Hay, Australia 1967</td>
<td>Hess et al. (1981)</td>
</tr>
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<td>KANSAS 1968</td>
<td>Kansas, USA 1968</td>
<td>Izumi (1971)</td>
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<tr>
<td>ITCE-1968</td>
<td>Vancouver, Canada 1968</td>
<td>Miyake et al. (1971)</td>
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<td>ITCE-1970</td>
<td>Tsimlyansk, Russia 1970</td>
<td>Tsvang et al. (1973)</td>
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<tr>
<td>ITCE-1961</td>
<td>Tsimlyansk, Russia 1985</td>
<td>Tsvang et al. (1985)</td>
</tr>
<tr>
<td>Lövsta</td>
<td>Lövsta, Sweden 1986</td>
<td>Högström (1990)</td>
</tr>
</tbody>
</table>
## Modern Experiments

### FIFE experiment 1987-89

**Typical dimensions:**
- 3-D experiment
- continuously (month-years)

### Table: FIFE experiments

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Location, Time</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>HAPEX-MOBILHY</td>
<td>France 1986</td>
<td>André et al. (1990)</td>
</tr>
<tr>
<td>KUREX-88</td>
<td>Kursk, Russia 1988</td>
<td>Tsvang et al. (1991)</td>
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<tr>
<td>SANA</td>
<td>Eisdorf, Melpitz, Germany 1991</td>
<td>Seiler (1996)</td>
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<tr>
<td>SHEBA</td>
<td>Arctic 1998</td>
<td>Utal et al. (2002)</td>
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<tr>
<td>LITFASS-98</td>
<td>Lindenberg, Germany, 1998</td>
<td>Beyrich et al. (2002b)</td>
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<tr>
<td>CASES-99</td>
<td>Kansas, USA 1999</td>
<td>Poulos et al. (2002)</td>
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<tr>
<td>EBEX-2000</td>
<td>near Fresno CA, USA, 2000</td>
<td>Oncley et al. (2007)</td>
</tr>
</tbody>
</table>
Atmospheric Scales

Space

Time
Scales of Experiments

- Large scales need horizontal field measurements
- Small scales need vertical measurements

Recent models of meso-β,γ scale need boundary layer and surface layer (fluxes) measurements, which are often not available (the wind profiler network is not dense enough)
Scales of Measuring Technique

<table>
<thead>
<tr>
<th>measuring system</th>
<th>macro</th>
<th>meso</th>
<th>micro</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>β</td>
<td>α</td>
<td>β</td>
</tr>
<tr>
<td>radio sonde</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>boundary layer sonde</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>tower &gt; 100 m</td>
<td></td>
<td></td>
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<tr>
<td>mast &lt; 50 m</td>
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<td></td>
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<tr>
<td>turbulence measuring technique</td>
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<td></td>
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<tr>
<td>satellite (vertical resolved)</td>
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<tr>
<td>wind profiler</td>
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<tr>
<td>Sodar</td>
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<td></td>
<td></td>
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<tr>
<td>RASS</td>
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<tr>
<td>LIDAR</td>
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</tbody>
</table>

Experiments need measuring technique of the process-adequate scale (different types)
Atmospheric Scales

Space

LES, LAS

Flux measurements, Footprint modeling

Meso-scale modeling (MM5, WRF, COSMO-DE)

Scale of Heterogeneities
$10^2 - 10^3$ m, 0.5 - 10 min.

Time
Structure of Modern Experiments

- Experimental area of the meso-β,γ scale with horizontal and vertical network

- Supersites of the micro-α, β scale with horizontal and vertical network including surface fluxes and plant and soil measurements
"Mesonet" is a combination of the words "mesoscale" and "network":
Space: 1-200 km, time: minutes to hours,
Meso-scale weather events and phenomenon: Thunderstorms, wind gusts, heat bursts, and dry lines, etc.
The COPS Experiment 2007

- Supersites, but mainly for remote sensing technique
- Surface and boundary layer measurements separated
CEOP-Network as Basis for Future Experiments

- Soil measurements
- Surface fluxes
- Boundary layer
- Ground truth !!!
Ecological Measurements - FLUXNET

- Carbon dioxide fluxes
- Soil and plant ecological measurements
- No connection to boundary layer

- Fluxes in and above the canopy
- Soil and branch measurements
- Combination with boundary layer

Gravity wave  LLJ

Ozone in and above the canopy

- Concentration on chemical reaction
- Meteorology is often reduced on standard weather stations
Horizontal Array Turbulence Study – HATS

- Investigation of micro-scale turbulence
- LES parameterization
- Canopy-HATS (BAMS 2011)
Availability of data and data quality

- Collection of the data in a uniform format (like NetCDF)
- Including of meta-data
- Flagging system for data quality on the basis of a QA/QC system
- Open access to the data for all participants and for others after a certain period (co-authorship or acknowledgement for data producers)
- No political restrictions by some countries
Criticism: Inefficient financial structure

- Missing sources for full financial support of experiments (or combination of sources)
- Financial support from different sources has the problem of financial and experimental gaps
- Because of financial limitation not always all necessary specialists and measuring systems are included
- Financial support for planning (including modeling) and a longer data analyzing period is often missing
Criticism: Development of new measuring systems

- The development starts often from zero and long-term experiences are ignored – old errors will be done again
- Companies have a high technical experience but no meteorological experience
- Experimentators work as β-tester
- Significant influences on experiments
Criticism: Ecological and Chemical Measurements

- Atmospheric Chemistry is often only homogeneous or heterogeneous gas-phase chemistry
- Ecological and chemical measurements have often only standard meteorological measurements
- Relevant atmospheric measurements are necessary on the scale of ecological and chemical experiments (often vertical profiles and fluxes)
- Definition of a process relevant Damköhler number: Adequate meteorological measurements are necessary, if the meteorological time scale is faster than the ecol/chem process time scale
Conclusions

- CEOP stations as a basis ground truth for modeling and remote sensing and for meso-scale and other experiments
- New forms of financial structure for experiments
- Including specialists and long-term experiences into all phases of an experiment
- Creation of data sources including meta-data and data quality information

- .... new methods and ideas to support meteorology with relevant experimental approaches and data