2012-2013 ICTP POSTGRADUATE DIPLOMA PROGRAMME
EARTH SYSTEM PHYSICS

Specific Topics on Atmospheric Monitoring and Extreme Events (ESP-ST)
(12 lectures : 18 hrs)

Lectures given by F. Stel

Lecture 1.
Definition of instrumental meteorology. Need for measurements and basic variables for atmospheric science. Direct, indirect and derived measurements. Conceptual model of a general monitoring system.

Lecture 2
Pressure definition and measurements. Hydrostatic and hydrodynamic components. Hydrodynamic drag of precipitations and its role in deep moist convection development. Pressure fields beneath deep moist convection.

Lecture 3
Solar irradiance, and solar irradiance monitoring devices. Temperature definition and monitoring devices.Potential temperature and entropy. Virtual temperature.

Lecture 4
Wind field measurements. Mechanical, electronic and sonic anemometers. Points of strenght and weakness. Main flow, gusts and turbulence.

Lecture 5
Moisture measurements. Dew point and wet bulb temperature measurements. Psycrometric equation. Homogeneous and eterogeneous water condensation and its role in Earth-Sun energy budget. Experiments.

Lecture 6
Precipitation definition and monitoring devices. Rain gauges and disdrometers. Wind field and effects on rain measurements (side effect). Introduction to remote sensing and RADAR equation.

Lectures given by D. Giaiotti

1. Basic Concepts

- Definition of extreme weather event. Not an easy task.
- Extremes in intensity and in frequency.
- Intensity – Frequency probability density function.
- How to summarize Intensity – Frequency pdf.
- Milestones of extreme weather event definitions.
- Extreme events and risks.
- Extreme events and losses estimates
- Summary of the basic concepts.

2. Temperature field

- Extremes in temperatures
- Extreme temperatures and climate change
- Extreme temperatures on a regional scale
- Extremes in surface temperature (nearly the ground)
- Extremes aloft (in the vertical profiles)
  - Troposphere
  - Stratosphere
  - Mesosphere
  - Thermosphere
- Extremes on averages (weekly, monthly, climate ...)
- Extremes on peaks (deviations from the average)

3. Precipitations and Droughts

- Extremes in precipitation; two aspects: floods and droughts.
- Large scale precipitation extremes.
- Extreme precipitations on a regional scale
- Extremes on averages (weekly, monthly, climate ...)
- Extremes on peaks (deviations from the average)
- Long term extremes, that is precipitations events lasting (lacking) for several days
- Large spatial scale floods
- Droughts
- Short term events, which have a sub-daily length, down to tens of minutes.
- Flash floods – small spatial scale events

4. Tropical Cyclones

- Tropical cyclones as a source of extremes
  - Definition of Tropical Cyclones
  - Features of the Tropical cyclones
  - Distribution of Tropical Cyclones
  - Evolution of the Tropical Cyclones
  - Weak aspects in our Tropical Cyclones knowledge
- Cyclones are primary sources for extremes in two important weather fields:
  - Wind – transfer of momentum from air to other systems
  - Precipitations – efficiency in condensating water vapor
- Secondary sources of extremes and related risks
  - Surges, runoff
- Tropical Cyclones and climate change
- Forecasts of the tropical cyclones
- Case studies

5. Extra-tropical Cyclones

- Extra-tropical cyclones as a source of extremes
- Ingredients for extra-tropical cyclones formation are:
  - baroclinic instability;
  - geostrophic balance
- Correlation between between losses and global circulation events
- Damages produced by storm surges
- Planetary and Rossby waves and extra-tropical cyclones

- Extra-tropical cyclones from satellite
- Cyclones are primary sources for extremes in two important weather fields:
  - Strong winds
  - Heavy precipitations
  - Deep atmospheric convection is embedded in the ETC (cold front)
- Secondary sources of extremes and related risks
  - Surges, runoff
- Extra-tropical cyclones and climate change
- Case study: ETC Xynthia February 26-28, 2010 – casualties and damages

6. Mesoscale and Microscale Severe Weather Events

- Deep tropospheric convection and extreme events
  - Mesoscale phenomena
  - Microscale phenomena
- Ingredients for convective extreme events
- Extremes associated with Mesoscale and Microscale Severe Weather Events
  - Strong vertical motions (> 30 m/s).
  - Strong horizontal motions (> 100 m/s).
  - High efficiency in condensating water vapor.
  - High efficiency in separating electrical charges.

- Deep tropospheric convection produces extremes in:
  - precipitation in several forms:
    - intense rainfalls which are related to: flash floods, landslides;
    - intense hailfalls
    - intense snowfalls
  - intense electrical activity
    - large fluctuation of the Earth electrical field
    - lightning strikes

- Deep tropospheric convection produces extremes in wind speed in several forms:
  - intense updrafts;
  - intense downdrafts;
  - strong turbulence;
  - large values of wind shear (both horizontal and vertical);
  - Intense atmospheric vortexes – high horizontal wind speed
- Definition and features of:
  - Supercell
  - Mesocyclone
  - Tornado
- Case studies

7. Natural Extreme Pollution Events

- Examples of extreme events related to pollutants release in the atmosphere
- Deterministic forecasts of atmospheric natural pollution extreme episodes
- Atmospheric natural pollution extreme episodes feedback
- Case study:

- Iceland's EyjafjallajÃ¶kull Volcano burst on March 20, 2010.

8.Extreme Value Distributions

- Definition of extreme value distribution
  - Basic theoretical concepts

Essential Bibliography

Climate Change 2013: The Physical Science Basis (http://www.ipcc.ch/)
From Climate Change Synthesis Report adopted section by section at IPCC Plenary XXVII (Valencia, Spain, 12-17 November 2007
Workshop Report - IPCC Workshop on Changes in Extreme Weather and Climate Events Beijing, China 11 – 13 June, 2002
Atmospheric convection : research and operational forecasting aspects. Dario B. Giaiotti et al. (eds.) - 2007 - Wien : Springer, 2007. - 226 pp ICTP Library shelf number: 551.59 ATM which is also available on the Diploma Students reference book shelf, in the ICTP library.
Fourth European conference on severe storms (ECSS 2007) : lecture notes and abstracts, ICTP, Trieste, 10-14 September 2007 Directors: N. Dotzek, D.B. Giaiotti, F. Giorgi, R. Jayaratne and F. Stel. ICTP Library shelf number: 551.50 TRI 2007
Extreme value distributions: theory and applications. by Kotz, S. and Nadarajah, S. - London Imperial College Press - 2000 - 185 pp ICTP Library shelf number: 519.21 KOT
Statistical analysis of extreme values with applications to insurance, finance, hydrology and other fields. 2nd ext. ed by Reiss, R. D. and Thomas, M. - Basel Birkhauser - 2001 - 443 pp ICTP Library shelf number: 519.24 REI

Supplementary bibliography

[1] C. F. Bohren and B. H. Albrecht, Atmospheric Thermodynamics (Oxford University Press, 1998).
[2] J. A. Dutton, Dynamics of the Atmosphere motion (Dover Publication Inc., 1995).
[3] D. B. Giaiotti and F. Stel, PhD course on Environmental Fluid Mechanics - University of Trieste (2007).
[4] D. B. Giaiotti, R. Steinacker, and F. Stel, Atmospheric Convection: Research and Operational Forecasting Aspects, vol. 475 - CISM Courses and Lectures (SpringerWienNewYork, 2007).
[5] A. E. Gill, Atmosphere - Ocean Dynamics (Academic Press, 1982).
[6] J. R. Holton, An Introduction to Dynamic Meteorology (Academic Press, 1972), 3rd ed.
[7] H. R. Pruppacher and J. D. Klett, Microphysics of clouds and precipitation (Dordrecht Kluwer Academic Publishers, 1997).
[8] G. Visconti, Fundamentals of Physics and Chemistry of the Atmosphere (Springer-Verlag Berlin, 2001).
[9] R. Zellner, Global Aspects of Atmospheric Chemistry, vol. 6 - Topics in Physical Chemistry (Springer, 1999).