WMO-CAgM – OPAG 4
Report of Expert Team on Guidelines on Education and Training in Agromet (ET4.2)

First Draft REPORT

OPAG 4 Capacity Developement in Agricultural Meteorology
Chairperson: E. Mateescu(RA I)
Co-chairperson: J. Ukeje (RA II)

ET 4.2 - Guidelines on Education and Training in Agromet (ET4.2)

Team members:
Sayed Masoud Mostafavi Darani, RA VI (I.R.Iran), Leader
Rebecca Manzou, RA I (Zimbabwe)
Feiyun Yang, RA II (China)
Homero Bergamaschi, RA III (Brazil)
Patrick Cherniski, RA IV (Canada)
Ahmad Mohamad Zaki, RA V (Malaysia)
Valentina Grigoryan, RA VI (Armenia)

28-29 November 2017- Geneva

CONTENT

Chapter 1.

Introduction

1.1. Background and overview

Training and education is a fundamental need in any discipline including agrometeorology but it must be ensured that the training and education needs and tools remains up to date. The Commission for Agricultural Meteorology (CAgM) was established in 1913 officially and unlike other Technical Commissions of the WMO, its terms of referrences (TORs) mainly have not been change till now and education and training has been highlited in TORs. As a interdisciplinary applied science, agricultural meteorology needs more attention.

The Commission for Agricultural Meteorology (CAgM) continuously reviews the requirements for training, education and extension in agricultural meteorology and recommends developments in programs of higher education, programs of training for agrometeorological technicians, and at other vocational levels where agrometeorology is involved.

The Commission for Agricultural Meteorology (CAgM) of WMO at its XVI Session (2014) established Open Panel of CAgM Experts (OPCAMEs) with 4 Focus Areas and now the Focus Area 4 is being devoted to capacity development in agricultural meteorology.

This report shows the contribution of the Experts Team on Guidelines on Education and Training in Agromet (ET4.2) based on their expertise in the field of education and training in Agrometeorlogy. The first meeting of the ET4.2 was held in Bucharest (Romania), 12-14 April 2016, when the experts team have been reviewed and established the final ToRs in order to elaborate a comprehensive Report.

Terms of Reference includes:

a) Review existing WMO publication on Guidelines for Curricula in Agricultural Meteorology, Supplement No. 2 (WMO-No. 258) and the Manual on the Implementation of Education and Training Standards in Meteorology and Hydrology (WMO-No. 1083);

b) Transform the existing curricula in (WMO-No. 258) into learning outcomes per WMO-No 1083;

c) Develop a new supplement for WMO-No 1083 for agricultural meteorology ;

d) Make an inventory of existing and available agricultural meteorological textbooks for a range of levels of formal education and informal training;

e) Make recommendations based on the review in (d) to CAgM on which agricultural meteorological textbooks are suitable;

The structure of this Report contains 7 Chapters that refers to:

1) Introduction

2) Review existing WMO publication on Guidelines for Curricula in Agricultural Meteorology, Supplement No. 2 (WMO-No. 258) and the Manual on the Implementation of Education and Training Standards in Meteorology and Hydrology (WMO-No. 1083)

3) Transform the existing curricula in (WMO-No. 258) into learning outcomes per WMO-No 1083

4) Develop a new supplement for WMO-No 1083 for agricultural meteorology

5) Make an inventory of existing and available agricultural meteorological textbooks for a range of levels of formal education and informal training

6) Make recommendations based on the review in (d) to CAgM on which agricultural meteorological textbooks are suitable

7) Results and general recommendations

1.2. Opportunities, constraints and limits for education and training in Agrometeorology

Introduction

Agricultural Meteorology as a multidesciplinary science is an applied branch of meteorological/climatological science and therefore could draw more attentions than other pure sciences. The enduser's needs in the field of agricultural meteorology are a considerable potential and that is an exceptional and educational opportunity. As those needs are different between developing and developed countries, the requirements for educational and training are different and must be considered.

Despite of education, training is more specific, job oriented and usually short duration. As it was determined in the ET4.2 expert meeting (Bucharest, 12-14 April 2016), because of above mentioned diverse needs, only formal education will be discussed in this report.

The operational application of agricultural meteorology is dependent on three basic conditions: 1. The availability of a suitable data base and infrastructure. 2. The provision of accurate and timely information 3. The services must be economically beneficial to the custumer (farmer, advisor, agriculture commodity trader, etc). For performing these tasks, appropriate coordination and cooperation between NHMs and agricultural ministries and good inter-ministral cooperation is essential and this is a limitation because lack of inter-ministral cooperation has been reported in different regions of WMO. However, special training courses in agrometeorlogy for different experts and technicians of agricultural ministries is a recommended solution. These training courses could be held by professional agrometeorologists.

A successful example of inter-ministral cooperation for training in the field of agricultural meteorology has being done by IRIMO (I.R. of Iran Meteorological Organization) and in line with WMO strategic plan. A comprehensive climate information service (TAHAK)[1] project was initiated since 2014 and one of the important part of this 7 steps' project is capacity building. 200 workshops has been held for introducing applied agrometeorology and its economic benefits to the experts and administratives of agricultural ministry and agriculture NGOs and 6152 participants have been participated in the workshops. Over the past three years (2014-2016), TAHAK became operational in all 31 provinces of Iran and 1,200,000 of farmers have been involved to the program, covering different agricultural fields of: honey production, olives, shrimp, dates, apples, grapes, wheat, rice, poultry and ostriches farming, bees and etc. The value Added of services in this system in the last crop year of 2015-16 (1394-95 in Persian calendar) and in the 11 provinces is estimated to be 110000 USD.

Constrain in Education and Training in Agrometeorology:

- Educating and training require financial investment. A one-time major investment in establishing communication technologies in the required places restricts the government's objective of covering more people regularly because of insufficient power availability in rural areas, poor ICT infrastructure, ICT illiteracy, non availability of timely relevant content, non-integration of services, poor advisory services and in particular non availability of agricultural information kiosks/ knowledge centers at the grass root level.
- Moreover, farmers sometimes become averse to adopting technology as they think that it might result in their losing their traditional methods of cropping practices. They simply do not want to use such systems, even if the cost incurred is negligible. Therefore, the attitude and mindset of farmers needs to be changed first. There is a need to win their confidence and create awareness about the benefits of ICT in agriculture.

[1] TAHAK is a Persian abbreviation means "development of meteorological application for end users"

Chapter 2.

Task a) Review existing WMO publication on *Guidelines for Curricula in Agricultural Meteorology,* Supplement No. 2 (WMO-No. 258) and the *Manual on the Implementation of Education and Training Standards in Meteorology and Hydrology* (WMO-No. 1083)

The Guidelines for Curricula in Agricultural Meteorology, Supplement No. 2 (WMO-No. 258) published in 2009 and it has been the result of an expert meeting on review of curriculum in agricultural meteorology. The Guideline was developed in three areas: the undergraduate programme, the postgraduate programme, and the training of intermediaries that the latter will not be considered in this report according to the results of the Bucharest meeting (12-14 April 2016). The Guideline includes 7 chapters.

The Manual on the Implementation of Education and Training Standards in Meteorology and Hydrology (WMO-No. 1083) was published in 2012 (2012 edition) but it was revised in 2015 and its name was changed to (Guide to the Implementation of Education and Training Standards in Meteorology and Hydrology - WMO-No. 1083) but the changes are not drastic and have been limited to the titles and sutitles.

Chapter 3.

Task b) Transform the existing curricula in (WMO-No. 258) into learning outcomes per WMO-No 1083

3.1. Transform the existing curricula in (WMO-No.258) into learning outcomes per WMO-No. 1082

Learning outcomes are statements that specify what learners will know or be able to do as a result of a learning activity. Outcomes are usually expressed as knowledge, skills, or attitudes. Learning outcomes have three distinguishing characteristics.

(1) The specified action by the learners must be observable.
(2) The specified action by the learners must be measurable.
(3) The specified action must be done by the learners.

The ultimate test when writing a learning outcome is whether or not the action taken by the participants can be assessed. If not, the outcome probably does not meet all three of the characteristics.

In other words, learning outcomes are the skills and knowledge that a student will be able to demonstrate upon completion of the learning process. When designing a programme of learning on an 'outcome based' model it focuses on what the student is expected to be able to do at the end of a period of learning whether it's a single module or whole degree programme. As they are written with this in mind it should make it easier for the students to understand what is expected of them.

On a programme level, learning outcomes are very broad and relate to the knowledge and skills students have developed over the whole degree: e.g. analyse, synthesise and summarise primary and secondary information critically, to formulate and test hypotheses; evaluate the relevance and significance of data; draw conclusions.
Module learning outcomes are much more specific and as such they should determine the content, delivery and assessment of the module. They are written in the future tense and as such are statements of achievement written from the learners' perspective and therefore when the assessment for the module is written it should have one or more learning outcomes.

Proposed & Recommendations on task b & Recommendations for edition (WMO-NO.1083)

Page3-Line38
3.3. (a) Foundation topics in mathematics, physics and agrometeorology plus complementary…….
Page4-Line11 (must be inserted)
3.3. (b)
- agrometeorology (i.e., fundamentals of meteorology and climatology, weather, climate and crops, livestock, meteorological hazards in agriculture, agrometeorological measurements and instrumentation, micrometeorology, coping with climate change and climate variability, tactical decision-making based on weather information, strategic use of climate information)

Page3-Line20
3.4. (b) Topics in ……basic climatology, basic agrometeorology
Page 12-Line 8(must be inserted)
8.3……. - Agrometeorology

Page 12- Line 8 (Appendix B)-Could be located in Page 40

APPENDIX B

5. Agricultural meteorology

Agricultural meteorology (Agrometeorology) according to the Guide to Agricultural Meteorology Practices (WMO-NO.134) is concerned with the meteorological , hydrological, pedological and biological factors that affect agricultural production and with the interaction between agriculture and the environment. According to AMS (American Meteorological society) Glossary, this discipline may emphasize atmospheric transport of insects, pathogens, etc., that impact agriculture as well as energy and mass exchange of plants and animals with the atmospheric environment. The effect of soils and vegetation on the ratio of sensible and latent energy exchange is representative of the impact of agriculture on meteorology.

Page 12- Line 11 to 22

8.4. ……..between five basic……..division into five subject areas……..in terms of the five meteorological disciplines……..according to the five meteorological disciplines……..

Part II-Basic Instruction package for meteorologists

Page 14

Line 4- …….agrometeorology and climatology.

Line 18-…….on agriculture and society.

Line 39.....

2. Completion of a degree in mathematics or a physical and agricultural science before studying the ……..

Page 17- Line 13

3. Topics in atmospheric sciences...change to ....Topics in meteorological sciences

Page 17-Line 20

Agricultural Meteorology ...could be added

Page 28-At the end of the page all of bellow mentioned materials could be added.

3.5 Agrometeorology

An individual achieving the learning outcomes dealing with agrometeorology shall be able to:

-Describe various basic aspects of agrometeorology and how weather and climate affect crop growth, development and yield and the interaction between weather/climate and agriculture for both crop and animal production and agricultural practices, understand meteorological hazards in agriculture and role of wind movement and the dynamics of wind flow over different surface in energy and mass exchanges. Understanding weather and climate as risk factors in agricultural production, risk assessment methods, mitigation and insurance.

-Monitor, observe and measure various weather parameters required for agrometeorological activities, evaluate wind-flow data and estimation of boundary structure and dynamics for agrometeorological application, using different analytical tools and methods, using climate information in the near future, Issuing and applying early warnings for extreme meteorological events, understand problems and solutions in designing, issuing and applying weather-related tactical applications.

-Understanding the characteristics of climate variability and climate change and how farmers can adapt to them, issuing and applying climate forecasts for coping with climate variability and climate change.

3.5.1 Fundamentals of meteorology and climatology

Learning outcomes-able to handle:

-Explain the earth and atmospheric composition and structure, Sun, the earth and seasons, Different meteorological elements and their instruments for the measurements, climate classification, Climatology of specific countries, climate change and global warming;

-Describe Heat balance and hydrological cycle, Cyclones and anticyclonic motions, El Nino and the Southern Oscillation, Atmospheric and soil drought;

-Explain air masses and fronts, clouds and their classification, weather charts, forecasting methods: short, medium and long-range forecasting techniques, recent models used in forecasting and their limitations in, and impact on agriculture, Numerical weather prediction;

-Describe climatic classifications, Agroclimatic indices and different agroclimatic zones, Frequencies of disastrous weather events in different regions, Atmospheric and soil drought, Monsoons and elements of monsoon meteorology.

3.5.2 Weather, Climate and crops

Learning outcomes-able to handle:

-Describe how weather and climatic factors affect plant growth and development, climatic water budget as a tool for agroclimatic analysis, weather/climate and crop yield relationship and an introduction to crop weather modelling, weather hazards and their impact on crop production;

-Use of weather and climate forecast in agriculture, basic concepts of climate data use for crop planning and climatic risk assessment: crop zoning;

-Analyse basic concepts of weather data use for decision-making in relation to agricultural operations: operational agricultural meteorology.

3.5.3 Weather, climate and livestock

Learning outcomes-able to handle:

-Describe the effect of climatic factors (temperature, radiation, humidity, wind) on thermal balance in animals, animal energy exchange processes and the need for the maintenance of thermal balances in animals;

-Analyse thermal indices for animal studies and management, physiological and productive consequences of environmental stresses and extreme weather events: loss of water from the body, growth rate and body weight, food intake, milk production, and so on;

-Diagnose adaptive capacity for the alleviation of climatic stress and climate change in livestock, contribution of animal husbandry to climate change and adaptation strategies to reduce the resulting effects.

3.5.4 Meteorological hazards in agriculture

Learning outcomes-able to handle:

-Explain the definitions; economic and social impacts; statistical climatology of drought; causes; forecasting droughts (analogue, statistical, physical);

-Explain the definitions, causes, damages, spatial and temporal distribution of drought, hail, frost, floods, pests and diseases, storage losses, fires, wild fires, extreme temperatures, winds and tsunamis;

-Analyse forecasting, monitoring, early warning and effects of drought, hail, frost, floods, extreme temperatures, winds and tsunamis on agricultural productions;

-Use of geographical information systems to improve prediction, and so on;

-Assess artificial simulation of precipitation: principles and practices of cloud seeding; problems of evaluation of experimental and operational programmes.

3.5.5 Micrometeorology

Learning outcomes-able to handle:

-Explain the turbulence mechanisms and characteristics to evaluate exchange of momentum, energy and mass in the atmospheric boundary layer, evaluation of the structure, dynamics and processes of diffusion and turbulent transfer using exchange models;

-Evaluation of the turbulent kinetic energy, stratified flows and stability parameters required to estimate coupled momentum and energy and mass exchanges;

-Analyse turbulence and wind profiles near the earths surface, influence of changing soil surface properties on wind flow dynamics, measurements and empirical relationship of wind and temperature profiles over different surfaces;

-Apply and control of the physical environment through irrigation, windbreaks, frost protection, manipulation of radiation and water use through intercropping systems;

-Assess simulation of boundary layer structure and dynamics, micrometeorology of crop canopies and animal environment, distribution of radiation, temperature, humidity, vapour pressure, wind and carbon dioxide.

3.5.6 Analytical tools and methods of agricultural meteorology

Learning outcomes-able to handle:

-Describe agroclimatic methods and elements, atmospheric sampling; temporal and spatial considerations; micro, meso and macro climates;

-Analyse network spacing; spatial and temporal methods, Geographical Information System fundamentals and applications, numerical characterization of climate features, crop response to climate, time lags, time and distance constants and hysteresis effects, influence of climate on stress-response relations, thermal time approach in agroclimatology: heat and radiation use efficiency in crop plants;

-Apply insect-pest development and prediction, comfort indices for humans and animals, agrometeorological experiments;

-Diagnose instrumentation and sampling problems, impact of natural and induced climate variability and change on crop production;

-Explain empirical and statistical crop weather models and example of their application; impact of natural and induced climate variability and change on crop production;

-Apply base knowledge of computer use in agriculture, the theory of programming languages: BASIC, FORTRAN, C, C++and visual BASIC;

-Use of empirical and statistical crop weather models and examples of their application, weather, soil, plants and other environment-related parameters as subroutine and remote-sensing inputs in models, groeth and yield prediction models, crop simulation models, forecasting models for insects and diseases.

Part III-Basic Instruction Package For Meteorological Technicians

Page 29- Line 6.....basic agricultural meteorology must be added.
Page 36- At the end of the page, below materials could be added
3.5 Agrometeorology
3.5.1 Agrometeorological measurements and instrumentation
Learning outcomes-able to handle:
-Describe the fundamentals of measurement techniques, theory and working principles of various instruments, electronic circuits, various sensors and equipments used in agrometeorological research and applications (barometers, thermometers, thermographs, psychrometers, hair hygrometers, thermohygrographs, raingauges, self-recording raingauges, Duvdevani dew gauges, sunshine recorders and pyranometers, lysimeters, open-pan evaporimeters, anemometers, wind vanes, anemographs, soil thermometers);
-Explain soil flux plates and instruments for measuring soil moisture, albedometers, photometers, spectroradiometers and quantum radiation sensors, ceptometers, pressure bomb apparatus, photosynthesis systems and infra-red thermometers;
-Analyse discussions on instrument selection, sensor deployment and data acquisition, automatic weather stations and other electronic instruments, data logger and data transmission systems;
-Use and measurement of surface energy fluxes, remote-sensing measurementsby radar and satellite, working with the above instruments in the meteorological observatory, taking observations of relevant parameters and computation and interpretation of the data;
-Apply techniques for data verification and validation, methods for data quality assurance and data quality control in automated systems;
-Analyse missing data generation.

3.2. Recommendations on training needs to improve agrometeorological services

a) It is recommended that a comprehensive review is made of topics that should be included in the curriculum of Agricultural Meteorology, such as micrometeorology, bio-physics (including soils), crop physiology, farming systems, applications of agromet principles, and analytical tools.
b) Content – As Agromet covers a broad range of disciplines, in addition to basic meteorology the following must be included:
   - Courses on food security, climate change and land use planning
   - Guidelines for interactions with farmers
   - Climate services for farmers
   - Phenology modules – how to make observations & do ground-truthing
   - Climate variability & assess climate change impacts
   - Geography
   - Training farmers in use of new technologies (data application)
   - Specialized instrumentation for agromet (leaf wetness, soil temp & moisture, leaf temperature, micromet measurements)
   - Crop climate modelling
   - Awareness raising for policymakers (farmers day in parliament)
   - Coping with risk (including natural disasters, management options)

c) Applications of Agrometeorology – potential and new areas for inclusion:
   - New sectors – fisheries, forestry, livestock, transport, input management
   - Land use planning (wasteland)
   - Strategic applications

- GIS and remote sensing
- Data management (data mining & databases)

d) Learning Methodologies in Agricultural Meteorology (learning)

e) Service (course) Providers
   - Dependent on gender
   - Need for practical training sessions (field day, field visit, demos)
   - Virtual class with assignments, Automation can be useful (WxSYS, IMD), integration of ICT, communication, systems
   - Problem based learning (how to solve problems)
   - Private sector needs to be involved
   - More public-private partnerships
   - Close collaboration between agricultural and weather institutions
   - Global collaboration with regional and sub-regional organisations (i.e. CREAMS

f) Policies to foster and institutionalise agricultural meteorology:
   - Coping with drought and natural disasters linked to agriculture
   - Financial resources for training (global)
   - Encourage organisations to sustain agromet and experts
   - Regional-level (in country) infrastructure development
   - Scholarships and awareness raising at school age (agromet outreach to kids)
   - Agromet topics included at school level education (food security)
   - Urbanization and agromet (climate change)
   - Protection of met equipment (outreach)
   - Outreach at local level (community ownership)

g) Monitoring and Evaluation Mechanisms
   - Beneficial aspects
   - Evaluate how effective the training is
   - Teach effective evaluation methods
   - Economic assessment on the benefits of training (cost benefit analysis).

Chapter 4.

Task c) Develop a new supplement for WMO-No 1083 for agricultural meteorology

A new supplement for WMO-No 1083 for agricultural meteorology could be prepared according to the proposed recommendations written in this draft report.

4.1.Case study on Agricultural Meteorology formal training syllabuses in I.R.Iran (RAII)

Table(1)- Some syllabuses for Agricultural Meteorlogy in I.R.Iran

NO	Course name	Categories:Main/Optioinal/Specific	M.S	PhD	Core Competency
1	Statistics in Meteorology I	Specific	×		
2	Statistics in Meteorology II	Optional	×	×	
3	Observational methods and tools in agro-meteorology	Optional	×	×	
4	Effects of air pollution in agriculture	Optional	×	×	
5	Advanced agro-climatology	Optional	×	×	
6	Accurate measurements in agro meteorological research	Optional	×	×	
7	Investigation of Iran's climatic issues	Optional	×	×	Localization for the region
8	Desertification and control methods	optional	×	×	
9	Atmospheric hazards	optional	×	×	
10	Agro-meteorology forecasting	optional	×	×	
11	Drought analysis and crisis management	optional	×	×	
12	Climate Change	optional	×	×	
13	Climatic geography and water resources of	optional	×	×	Localization for the region

	Iran				
14	Bio-micrometeorology	optional	×	×	
15	Complementary RS	optional	×	×	
16	Agro-meteorology of specific crops	optional	×	×	Localization for the region
17	micrometeorology	optional	×	×	
18	Forest meteorology	optional	×	×	
19	Crop water requirement	optional	×	×	
20	New topics in agro meteorology	optional	×	×	

As the requirements and needs for agrometeorological services and related issues are different from region to region and even from country to country, it is essential to consider some related syllabusses in the curriculla. For example in the regions subject to drought, considering syllabuses related to drought would be very helpful. Three cases of such issues are indicated in table (1).

4.2. Case study on existing available institutions that offer education and training in agricultural meteorology in I.R.Iran

In the case of education in the fields of Agricultural Meteorology and Agricultural Climatology, There are 12 universities in I.R.Iran that offer Master and Phd degrees. As it can be seen in table (2), PhD and M.S degrees of Agricultural Meteorology are offered by 4 and 6 universities while PhD and M.S degrees of Agricultural Climatology are offered by 5 and 4 universities respectively.
Like many other countries, There is no B.S degree of Agrometeorology and Agroclimatology in I.R.Iran.

Table (2)- Universities that offer PhD & M.S in the fields of Agrometeorlogy and Agroclimatology in I.R.Iran

University	BSc	MSc	PHD
Tehran Universityt		Agrometeorology	Agrometeorology
Hamedan University		Agrometeorology	Agrometeorology
Mashhad University		Agrometeorology	Agrometeorology
Tehran Free university		Agrometeorology	Agrometeorology
Isfahan University		Agroclimatology	Agroclimatology
Tehran University		Agroclimatology	Agroclimatology
Sabzevar University			Agroclimatology
Ardebil University		Agroclimatology	Agroclimatology
NajafAbad Free University			Agroclimatology
Semnan University		Agrometeorology	

Shiraz University		Agrometeorology	
Tehran Kharazmi University		Agroclimatology	

4.3. Case study on existing available institutions that offer education and training in agricultural meteorology in Zimbabve

The universities in Zimbabve that offer Master and Phd degrees in Agricultural Meteorology are indicated in table (3).

Table (3)-Universities in Zimbabwe which offer courses related to Agro meteorology:

University	BSc	MSc	PHD
University of Zimbabwe	Honours in Physics • Meteorology • Environmental Physics (Levels 2 & 4)	MSc in Applied Physics Optional Course • Environmental Physics (MAPH531)	
	Honours in Meteorology Honours in Geography and Environmental Studies	MSc in Agricultural Meteorology Meteorology • Fundamentals of Meteorology and Climatology • Weather, climate and agriculture • Micrometeorology Climatology • Fundamentals of Meteorology and Climatology • Weather, climate and agriculture	Climate Change
Zimbabwe Open University	Geography and Environmental Studies • Introduction to weather and climate • Meteorology and Climatology		Climate Change
Africa University	Agriculture and Natural Resources	MSc in Crop Production AHC 505 Pomology	

	Environmental Science and Pollution (ANR201) • Climatic changes Agricultural Engineering Hydrology (AAE 304) • Elementary meteorology	• Climatic adaptation of tropical, subtropical and deciduous fruits. CP 505 Advanced Crop Production • Modelling and prediction of crop responses to environmental change. • Strategies for dealing with crop production in the changed environment. • Microclimate and crop production systems. MSc Animal Science AAS 506 Livestock and the Environment • Physical environmental variables. • Regulation of body temperature in homeotherms. • Environmental effects on animal production and reproduction; immune response, livestock pathology and carcass quality • Livestock housing and transport.	
Solusi	Environment Studies • Module		
Midlands State University	Agriculture • Agrometeorology • Climate Change	Agriculture • Agrometeorology • Climate Change	Climate Change
Bindura	Disaster Management		

NUST		MSC in Disaster Management	
Chinhoyi University of Technology			Climate Change
Lupane	Agriculture • Agrometeorology • Climate Change		

4.4. Case study on existing available institutions that offer education and training in agricultural meteorology in Brazil

DISCIPLINES IN AGROMETEOROLOGY FOR THE MAIN COURSES IN BRAZIL
(B.S., M.Sc., and Ph.D. courses)

1) ESALQ / USP - Piracicaba, Sao Paulo State

(Transition zone between subtropics and tropic - in the South-East region)

Comprised courses
Biological Sciences, Agricultural Engineering, Forest Engineering, Environmental Sciences
Disciplines in B.Sc.
Agrometeorology of Crops
Environmental Physics Analysis
Physics
Agricultural Environmental Physics
Physics to Biology
Agricultural Meteorology
Forest Meteorology
Climate Change and Agriculture

Disciplines in M.Sc. and Ph.D.

Agrometeorology and Plant Diseases
Climate and Agriculture: Principles and Applications
Climatological Statistics
Introduction to Micrometeorology and Evapotranspiration
Micrometeorology of Farming Systems
Modeling for Growth and Development of Agricultural Crops
Remote sensing for Agrometeorology

2) UFV - Viçosa, Minas Gerais State

(Tropical savanna zone - in the South-East region)

Comprised courses
Forest Engineering, Environmental Engineering, Animal Science, Agronomy

Disciplines in B.Sc.

Meteorology and Climatology
Introduction to Animal Climatology
Climatology
Thermodynamics
Heat and Mass Transfer
Soil-Plant-Atmosphere System

Disciplines in M.Sc. and Ph.D.

Atmospheric Physics
Agricultural Meteorology
Climatology Physics
Microclimatology
Quantitative Methods in Climatology
Agrometeorological Instrumentation
Hydroclimatology

3) UFRGS - Porto Alegre, Rio Grande do Sul State
(Humid subtropics - in the South region)
Comprised courses
Agronomy, Animal Science, Biological Sciences

Disciplines in B.Sc.

Basic Agrometeorology
Agrometeorology Applied to Irrigation
Agrometeorology for Animal Science
Applied Climatology
Meteorology and Climatology
Climate-Plant Relationships

Disciplines in M.Sc. and Ph.D.

Agrometeorology by Satellite

Water the Soil-Plant-Atmosphere System
Spectral Behavior of Targets
Ecology of Cultivated Plants
Meteorology and Climatology

4) UFSM - Santa Maria, Rio Grande do Sul State
(Humid subtropics - in the South region)
Comprised courses
Agronomy, Forest Engineering, Animal Science, and Agricultural Engineering

Disciplines in B.Sc.

Agroclimatology
Climatology for Animal Science
Agricultural Ecology

Disciplines in M.Sc. and Ph.D.

Physical Alterations in Agricultural Environments
Plant Biophysics
Climate Change Applied to Agroecosystems and Hydrological Resources
Micrometeorology of Agricultural Crops
Phenology of Agricultural Crops
Modeling for Crop Production

5) UFCG - Campina Grande, Paraiba State
(Semi-arid tropic - in the North-East region)
Comprised courses
Agronomy, Meteorology, Food Engineering

Disciplines in B.Sc.

Agrometeorology (for Meteorology)
Meteorology and Climatology (for Agronomy)
Agrometeorology (for Food Engineering)

Disciplines in M.Sc. and Ph.D.

Agricultural Meteorology
Micrometeorology
Water Relations in Soil-Plant-Atmosphere
Environmental Instrumentation
Introduction of Remote Sensing
Applied Remote Sensing
Statistic Methods and Climatology

Hydrometeorology
Applied Climatology
Heat and Mass Transfer in the Biosphere

6) UFRA - Belem, Para State
(Humid Amazon tropics - in the North region)
Comprised courses
Agronomy, Forest Engineering, Animal Science, Environmental Engineering

Disciplines in B.Sc.

Agrometeorology, Meteorology and Climatology, Forest Ecosystems, Ecology, Amazon Biomes and Environments

Disciplines in M.Sc. and Ph.D.

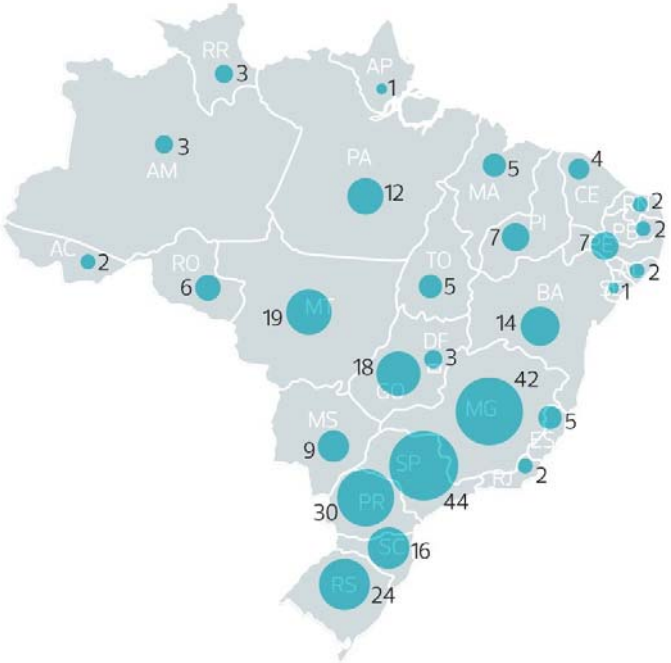
Experimental Agrometeorology

Inventory for B.S. courses in Agricultural Sciences in Brazil
that include disciplines in Agrometeorology and Climatology

1) Agronomy

According to the Resolution number 1, emitted in 02/02/2006 by the Ministry of Education and Culture (MEC), disciplines of Agrometeorology and Climatology must compose the courses of Agronomy, in Brazil.

Total number of courses in Agronomy, in Brazil: 288 (Figure bellow)



Source: Federal Council of Engineering and Agronomy (Confea), apud Globo Rural (Jan./2015)

2) Agricultural Engineering

According to the Resolution number 2, emitted in 02/02/2006 by the Ministry of Education and Culture (MEC), disciplines of Meteorology and Bioclimatology must compose the courses of Agricultural Engineering, in Brazil.

Total number of courses in Agricultural Engineering, in Brazil: 18

Source: Brazilian Society of Agricultural Engineering

3) Forest Engineering

According to the Resolution number 3, emitted in 02/02/2006 by the Ministry of Education and Culture (MEC), disciplines of Meteorology and Climatology must compose the courses of Forest Engineering, in Brazil.

Total number of courses in Forest Engineering, in Brazil: 73

Source: National System of Forest Information

4) Animal Science

According to the Resolution number 4, emitted in 02/02/2006 by the Ministry of Education and Culture (MEC), disciplines of Agrometeorology and Bioclimatology must compose the courses of Agronomy in Brazil.

Total number of courses in Animal Science, in Brazil: 82

Source: Brazilian Society of Animal Science

5) Meteorology

Total number of courses in Meteorology, in Brazil: 10

Source: UOL/Folha de São Paulo

4.5. Case study on existing available institutions that offer education and training in agricultural meteorology in China

Agricultural meteorology programmes for bachelor and masters degrees are offered at the following three universities in China:

(a) China Agricultural University (CAU);
(b) Nanjing University of Information Science & Technology(NUIST)
(c) Shenyang Agricultural University (SAU);

A summary of the courses offered by the universities is presented in Table 4.

Table (4)- Universities that offer PhD & M.S in the fields of Agrometeorlogy in China

College	Undergraduate Courses	Postgraduate Courses
NUIST	Applied Meteorology, Agrometeorology, Ecosystem Carbon Cycle, Geographic Information System, Science of Climate Resources, Agrometeorological Information Forecast, Science of Meteorological Services, Science of meteorological disasters, Application of Meteorological Instruments	Agrometeorological and ecological system simulation, experimental research method of applied meteorology, boundary layer meteorology, environmental physics principle, principle and application of remote sensing applied meteorology, biometeorology, ecosystem carbon cycle, science of crop model, agricultural biological environment control, agrometeorological disasters, biostatistics, new achievements of applied meteorology, etc
CAU	Introduction to Applied Meteorology, Principle and Method of Agrometeorology, Applied Climatology, Microclimatology, Applied Meteorological Statistics and	Advanced biometeorology, enrage interaction principle and measuring method, biological climate models and information systems, weather climate diagnosis and crop yield

	Mathematical Methods, Professional Basis of Meteorological Operations, Agrobiological Environmental Engineering, Applied Meteorology Monograph	forecast, natural disasters and mitigation technology
SAU	Basic Ecology, Applied Meteorological statistics, Applied Meteorological instruments, Biological Meteorology, Dynamic Meteorology, Weather Analysis and Forecast, Agrometeorological Services and Methods, Microclimatology, Climatology, Water Conservation Science and Applied Meteorology introduction, Environment and Regulation of Agricultural Facilities	Modern Weather Forecast Technology and Method, Progress in Research of Modern Climatology, Meteorological Statistical Analysis and Forecast, Numerical Calculation (Meteorology), Research Progress of Biometeorology. Remote Sensing of Environment, Application of Meteorological Instrument, Fuzzy Mathematics and its Application, the Foundation of Biological Environment, Geographic Information System

4.6. existing available institutions that offer education and training in agricultural meteorology in some countries

In most countries Agricultural Meteorology is taught at the post-graduate (PhD and M.S) level except for South Africa (Free state university) that it is taught at the undergraduate level. The table (5) shows the universities providing Agrometeorlogy course in different regions:

Table (5)-Universities providing agrometeorology courses in different regions leading to PhD and M.Sc except for I.R.Iran, Zimbabwe, China and Brazil

Region	Country	University
I	**South Africa**	**University of KwaZulu-Natal**
I	**South Africa**	**Bloemfontein-Free State (B.Sc degree, M.Sc & PhD)**
I	**Ethiopia**	**University of Haramaya**
II	**India**	**Assam Agricultural University**
II	**India**	**Gujarat Agricultural University**
II	**India**	**Anand Agricultural University**
II	**India**	**Tamil Nadu Agricultural University**
II	**India**	**Acharya Agricultural University**
II	**India**	**Haryana Agricultural University**
II	**India**	**Kerala Agricultural University**
II	**India**	**Madhya Pradesh-Indira Gandhi Agricultural University**
II	**India**	**Maharashtra- center of advanced studies in agrometeorology**

II	**India**	**Ranichauri, U.P. – G.B. Plant university of agriculture and technology**
II	**India**	**Pune-Centre of advanced studies in agricultural meteorology-College of agriculture, Mahatma Phule university**
II	**India**	**Punjab-Agricultural University**
II	**India**	**Visakhapatnam- Andhara University**
II	**Kazakhstan**	**Almata- University of Kazakhstan**
III	**Argentina**	**University of Buenos Aires**
IV	**Canada**	**University of Guelph**
IV	**U.S.A**	**University of California at Davis**
IV	**U.S.A**	**Columbus-University of Missouri**
IV	**U.S.A**	**Ames-Iowa State University**
IV	**U.S.A**	**Lincoln- University of Nebraska**
IV	**U.S.A**	**Logan- Utah State University**
V	**Indonesia**	**University of Bogor**
VI	**Belgium**	**Arlon- Foundation university Luxenbourgoise**
VI	**England**	**University of Reading and/or Nottingham**
VI	**France**	**University of Montpellier**
VI	**Netherlands**	**Wageningen-University and Research Center**
VI	**Israel**	**Rehovot- University of Jerusalem**
VI	**Austria**	**University of BOKU**
VI	**Italy**	**Sardinia-University of Sassari**
VI	**Italy**	**Firenze- University of Firenze**

Chapter 5.

Task d) Inventory of existing and available agricultural meteorological textbooks

Introduction

.....

Recommended sites for finding related books!

https://www.wmo.int

https://www.worldcat.org

http://www.bookfinder.com

http://www.bookfinder4u.com

5.1. existing and available agricultural meteorological textbooks

No	Author	Title	Publication	Year	ISBN
1	Kees Stigter	Applied Agrometeorology	Springer	2010	3540746978
2	180 contributors Coordinated by Kees stigter (editor-in-chief)	Guide to Agricultural Meteorological Practices (GAMP)-WMO-No. 134	WMO	2012	9263101341
3	Harpal S. Mavi & Graeme J. Tupper	Agrometeorology: Principles and Applications of Climate Studies in Agriculture	CRC Press	2004	1560229721
4	H.P. Das	Agrometeorology in Extreme Events and Natural Disasters	CRC Press	2012	0415621127
5	D. D. Sahu	Agrometeorology and Remote Sensing		2003	8177541986
6	S. D. Attri et al.,	Challenges and Opportunities in Agrometeorology	Springer	2014	3642431593
7	C. Baldy & C. J. Stigter	Agrometeorology of Multiple Cropping in Warm Climates	Science Pub Inc	1997	1886106924
8	Vijendra K. Boken et al.,	Monitoring and predicting Agricultural Drought: A Global Study	Oxford University Press	2005	019516234X
9	G. S. L. H. V. Prasana Rao	Agricultural Meteorology	PHI Learning	2010	8120333381
10	J. Warren smith	Agricultural Meteorology	BiblioLife	2010	1140164023

11	M.V.K. Sivakumar & J. Hansen	Climate Prediction and agriculture (Advances and Challenges)	Springer	2007	3540446494
12	M.V.K. Sivakumar & R.P. Motha	Managing Weather and Climate Risks in Agriculture	Springer	2007	3540727446
13	R. shofiyati	Remote Sensing and Geographical Information System Application: Agricultural Drought Monitoring and assessment Using Satellite Data	VDM Verlag	2009	3639205073
14	C. A. Iglesias et al.,	Coping With Drought Risk in Agriculture and Water Supply Systems: Drought Management and Policy Development in the Mediterranean	Springer	2009	1402090447
15	G. G. S. N. Rao	Droughts and Agricultural Production: Monitoring and Management	NEW INDIA PUBLISHING AGENCY	2015	9385516000
16	M. V. K. Sivakumar, R. P. Motha, H. P. Das	Natural Disasters and Extreme Events in Agriculture: Impacts and Mitigation	Springer	2010	3642061338
17	M. V. K. Sivakumar et al.,	Climate Change and Food Security in South Asia	Springer	2011	9401781354
18	J. salinger et al.,	Increasing Climate Variability and Change: Reducing the Vulnerability of Agriculture and Forestry	Springer	2010	9048168422
19	M. V. K. Sivakumar and N. Ndiangui	Climate and Land Degradation	Springer	2007	3540724370
20	M. V. K. sivakumar., R. selvaraju and I. Hamdan	Climate Change and Food Security in West Asia and North Africa	Springer	2013	9401783071
21	R. Stefanski and F. Pischke (Editors in chief) with 28 contributors	Handbook of drought indicators and indices	WMO	2016	9263111739
22	Pedgley D.E.	Windborne Pests & diseases: Meteorology of Airborne Organisms	Ellis Horwood Limited	1982	

23	Hatfield J.L.	Biometeorology in integrated pest management.	Academic press	1982	
24	Goodall D.W.	Ecosystems of the world 12B: Hot deserts & Arid Shrublands.	Elsevier	1986	
25	Sivakumar M.V.K. et-al.	Agrometeorology of Groundnuts: Proceedings of an International Symposium	International Crops Research Institute for the Semi-Arid Tropics.	1985	
26		Agro-meteorology: Proceedings of the 2nd International training course.	Leningrad Gidrometeorizdat	1988	
27	Sivakumar M.V.K.	Climate prediction & Agriculture: Proceedings of an international workshop.	International START Secretariat.	2000	
28	Beukema J.J. et-al.	Expected effects of Climatic Change on Marine Coastal Ecosystems.	Kluwer Academic Publishers	1990	
29	Tromp S.W.	Biometeorology	Pergamon Press	1962	
30	Clark J.A.	Environmental aspects of housing for animal production.	Butterworths	1981	
31	Levitt J.	Responses of plants to environmental stresses.	Academic Press.	1972	
32	Sivakumar M.V.K.	Climate and Land Degradation.	Springer	2007	
33	CGIAR	Publications on international Agricultural Research & Development.	International Rice Research Institute	1984	
34	Barrett E.C. & Curtis L.F.	Introduction to Environmental Remote Sensing 2nd.	Chapman & Hall	1982	
35	Clark J.A.	Environmental aspects of housing for animal production.	Butterworths	1981	

Chapter 6.

Task e) Make recommendations based on the review in (d) to CAgM on which agricultural meteorological textbooks are suitable

.....will be decided,

Chapter 7.

Recommendations

Many students can not transfer their learning during formal education into applications in the real world and it is same for agricultural meteorology. Problem-based learning was originally developed medical staff at McMaster university in Canada in the 1970s ad tries to solve the above mentioned problem. Students attending theory classes had to apply their newly gained knowledge coupled with real-life weather data to solve problem during practicums. De wet and Walker (2013) used this approach for students of agrometeorology in undergraduate level. The results showed that students of agrometeorlogy benefited from problem-based learning in that they improved their knowledge, skills, and critical thinking abilities and felt that they had learnt something that could benefit them throughout their future lives out in the world and the workplace.
According to the result obtained, the problem-based approach could be examined in different levels of academic education in Agricultural Meteorology.

References

- De wet, L and S.Walker (2013) students perceptions of problem-based learning: A case study of undergraduate applied agrometeorlogy, Hindawi Publication Corporation, ID 982942, 9 pp.

- Lomas, J., J. R. Milford, E. Mukhala., (2000) Education and training in agricultural meteorology: current status and future needs, Agricultural and Forest Meteorology 103: 197-208;

-Lomas, J et al., (?)Education and training in agricultural meteorology, CAgM Report No.78, WMO TD No.990, 35 pp.

- http://www.lib.utexas.edu/services/instruction/tips/cp/cp_goals.html

- https://www.nottingham.ac.uk/teaching/documents/guidance/lo-guidance.pdf

-Personal contact with Prof. Walker & Dr.stefanski

-Report of Implementation/Coordination Team (ICT 1.1) on Agrometeorological services, 2013, Puna, India