**Forest Meteorology**

**Course Objectives**

The aim of this course is to inform the students on the developments on forest meteorology, which is one of the most important application areas in the forestry science. Herewith, the value of forest meteorology for our country will be emphasized and the effects of the meteorological factors will be analyzed. Additionally, this course is necessary for the building of a base knowledge of the students who are going to take other forest course within the next courses.

## Course content

Forest Meteorology is a course at Master’s level. It is designed to emphasize forestry meteorology concepts while providing useful skills for using well-know meteorology models in simulating the impacts of climate change on forest.

## Learning outcome

Knowledge

You will learn how to:

classify and evaluate meteorology models

process and prepare data files for different models

use well-known models (e.g. RegCM4, etc) in climate variabilities assessment, in impact estimation of climate change and land-use change.

interpret, analyse and understand the model outputs

**Course Description**

Introduction.

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## Prerequisites

### Recommended previous knowledge

Bachelor courses in basic mathematics, statistics and Foresry/meteorology/climatology and physical geography.

## Teaching

Lectures (20 hours), computer work (10 hours),presentations (6 hours) and one written assignment that is based on data collected in the field.

# Lecture 1. Forest meteorology introduction

**(1)Statement**

Forest meteorology is a science of the study on the mutual influence and interaction between atmosphere and forestry.

From the subject classification, forest meteorology belongs to atmospheric sciences (level 1 discipline) and applied meteorology (level 2 discipline).It has two aspects: first, the study of weather or climate conditions on the influence of forest growth, development and production, and severe weather interference of forest tree, etc., belonging to the scope of meteorological application in forestry, i.e., the category of applied meteorology, just as the agricultural meteorology, medical meteorology applications, can be summed up in the forest meteorology. Second, the research of forest (including trees, forest zone, etc.) impact on the atmosphere, where the forest is looked as a impact factor acting on the process of atmospheric physics, such as terrain meteorology, tropical meteorology, and other meteorological branches, it does not belong to the category of applied meteorology, but a part of meteorology itself, so the question of the forest impacting on the atmosphere, is belongs to the forest meteorology.  
 All in all, it belongs to the interdisciplinary, needing the basis of forestry and meteorology.

**(2)Topic lectures**

(I) forest climate. It includes canopy climatology, forest microclimate, describing some special climate conditions because of underlying forest, like special sun radiation, precipitation, carbon dioxide, evaporation, transpiration, etc., and explaining the corresponding macro and micro reasons by means of physical mechanism of forest and atmosphere.

Forest plays an important role in the current global climate change. As main body of surface ecosystem, usually forest has the roles of fixing carbon releasing oxygen, water conservation, air purification, maintenance of soil and water conservation, all of these can adjust air condition and affect climate change. On the other hand, constantly changing climate also influence forest, such as vegetation zonal distribution, forest type, forest disasters and so on.

(II)forest and air pollution. This includes two aspects, one is the atmospheric purification effect of forest, forests can absorb dust and other particles, releasing sterilization of volatile substances, reduce noise and increase the air negative ions. The other is harmful gas endanger forest, such as acid precipitation, common is acid rain. In China, the acid rain is eroding the natural forest, it is shocking.

(III) Shelter forest climate effects: beach, windbreak, shelter belts to protect sea coast, water and soil conservation forests, etc., main of these is stopping wind.

(IV)forest and meteorological disasters. One is meteorological disasters affect forest, there are so many meteorological disasters linked with forest, such as lightning, severe wind, drought, flood, typhoon, hail, acid rain, high temperature, frost. The other is that artificial meteorological factors regulate can prevent forest disasters, like artificial hail elimination, artificial precipitation, remote sensing monitoring.

**(3)Round table discussions**

Our discussion topic today:

A. the trend, performance and reason of global climate change

B. PM2.5 in China

In connection with discussion topics, we will assign 1-2 journal articles. You are responsible to study the articles thoroughly before the discussion session and be ready to offer your comments on them and to engage yourself with fellow classmates during the session.

We will devote a session every week to analyze the assigned journal articles. Each session will be led by a student, as designated at the beginning of the semester. The lead student should start the session by answering discussion topics listed above from his/her own perspective, guide the discussion to ensure productivity, and finally, close the session by concluding remarks. Other students should participate in the discussion activity.

Lecture 2: meteorological model and forest

**(1)Statement**

From the perspective of the history of atmospheric research, the ultimate performance of atmospheric science is meteorological models, which is the direction of modern weather. Meteorological model is complex, but after all, it comes down to:



Where  means independent variable observations, subscript 0 is initial time. Where  means dependent variable that you want to know, subscript n is a certain moment in the past or the future.

Through meteorological model, the simulative data of non-observational-station area can be obtained in forest, in addition, we can acquire future climate change by means of meteorological model, which can provide technical and data support for forest vegetation growth and pest control. All in all, application of meteorological model is very important in forest research.

**（2）topic lectures**

(I) the development of atmospheric science

It is divided into four parts, the main experience is the process of data collection, the establishment of research theory, all of these is done for the numerical simulation, i.e., modern meteorology’s development direction.

(II)forest underlying information must be coupled into meteorological model

The surface and atmosphere are affected each other all the time. For forest underlying surface, the exchanging channels are respiration, photosynthesis, transpiration of vegetation, corresponding meteorological model must consider forest underlying conditions.

(III)future climate forecast for forest research

By means of predicting the future climate information of forest areas and master, it can provide support for forest protection, forest cultivation and sustainable development.

**(3)Round table discussions**

Our discussion topic today:

A. How to study the role of forest restraining global warming by means of meteorological model?

B. How to couple forest information in a meteorological model?

In connection with discussion topics, we will assign 1-2 journal articles. You are responsible to study the articles thoroughly before the discussion session and be ready to offer your comments on them and to engage yourself with fellow classmates during the session.

We will devote a session every week to analyze the assigned journal articles. Each session will be led by a student, as designated at the beginning of the semester. The lead student should start the session by answering discussion topics listed above from his/her own perspective, guide the discussion to ensure productivity, and finally, close the session by concluding remarks. Other students should participate in the discussion activity.

Lecture 3: vegetation and climate change

**(1)Statement**

In response to the global climate change research, the relationship between vegetation and climate change, regional and large scale vegetation activity and its response to climate change has become hot spots. Different Vegetation cover has different climate characteristics, corresponding investigation has been statistical analyzed by mean of geographic information system (GIS) technology, combining with data of Normalized Difference Vegetation index (NDVI, Normalized Difference Vegetation Indices), which can indicate vegetation cover information, and meteorological data. In view of the observational time limit, most of the study period lies in the 1980 s to the early 21st century, and conclusions have regional restrictions. But all of them show that vegetation coverage has close relation with temperature and precipitation.

There are two main types of research method. One looks observation as basic means, for example, main vegetation type NDVI data of north-south strip in east China, the response to climate is that NDVI data of temperate deciduous thickets is controlled only by air temperature at the interannual scale, while NDVI of temperate grass prairie and subtropical and tropical coniferous forest is adjusted both by temperature and precipitation. The other method uses model. Such as using the regional climate model (RegCM) to study the Yellow River source area, the result showed that different vegetation type brought different climate effects by means of changing underlying surface vegetation simulation, indicating that vegetation might increase air humidity and suppress temperature growth.

**(2)Topic lectures**

(I) the climate change trend in the study area.

(II) the mian vegetation condition, such as vegetation type, vegetation cover, etc.

(III) the observations, including RS and conventional observation

(IV) model and method

All the listed above have different characteristics, so the research will has different conclusions.

We take the middle and lower reaches of the Yangtze river area as an example, the corresponding is, (I)dry and hot in the following 100 years,

(II) subtropical evergreen broad-leaved forest,

(III) Spot\_vegetation data, meteorological observations, climate simulation data, MODIS terrain type, meteorological terrain simulation,

(IV)RegCM3 simulation, statistic method

**(3)Round table discussions**

Our discussion topic today:

A. the role of forest to precipitation? Increase only?

B. the role of forest to air temperature? Suppress only?

C. the distribution of vegetation strip and climate?

In connection with discussion topics, we will assign 1-2 journal articles. You are responsible to study the articles thoroughly before the discussion session and be ready to offer your comments on them and to engage yourself with fellow classmates during the session.

We will devote a session every week to analyze the assigned journal articles. Each session will be led by a student, as designated at the beginning of the semester. The lead student should start the session by answering discussion topics listed above from his/her own perspective, guide the discussion to ensure productivity, and finally, close the session by concluding remarks. Other students should participate in the discussion activity.

Lecture 4: lightning-caused forest fire

**(1)Statements**

Forest lightning disaster is a kind of important natural disasters. It comes from cloud to ground (cloud to ground lightning, i.e., CG lightning)thermoelectric effect by thunderstorm cloud, resulting in instantaneous ultra high temperature (6000-10000 ℃), causing hit trees inner water vaporize too quick to release, then disasters occur. Its performance mainly has two aspects:One is trees lodging, bombing, rotting, form forest gap, change the structure of forest community and succession dynamic, at the same time may cause plant diseases and insect pests in the coming year, it is one of the important natural factors that prompted trees die directly. The other lightning-caused forest fire combining with forests cover, fuel moisture, wind and other conditions, there are 7% - 10% lightning-caused fire in the all over the world forest fire, in China, the rate is up to 30% in northeast China and Inner Mongolia. Of cause the latter brings more harm than the former.

Appropriate meteorological condition is a necessary factor in the production of lightning-caused forest fire. In common, dry, warm weather condition is conducive to lightning-caused fire, such as the northeast and Inner Mongolia region in China. Some study suggests that the discharge process of lightning current from cloud to ground has ‘the wet trend’, so relatively humid forest areas are vulnerable to lightning interference, such as southeast Asia, lightning disasters is an important natural factors result in the death of a tropical rain forest trees. Study also gave that tree species easily affected by lightning in turn is pine, fir, broad-leaved and coniferous mixed, mixed needle leaf and so on.

With the global climate warming, lightning-caused forest fire disaster has a tendency to increase. 1 ℃ warming will lead to lightning activity increases by about 5% or 6%, the CG lightning will also increase, this will directly result in frequent forest lightning disasters. It is estimated that if the temperature heating up 4 ℃, lightning-caused forest fire area will increase 78%. In China, annual air temperature would rise by about 1.0 to 2.9 ℃ in the beginning and middle 21st century, so the research on lightning-caused forest fire is imminent under the condition of Chinese natural forest coverage being weak.

**(2)Topic lectures**

(I)study method.

Common methods use statistical technique and the corresponding statistical models. But due to local restrictions, statistical model may be no unity at various places. To break through the problem, maybe we can do something else. The study belongs to a crossover study, namely, meteorology and forestry, if thunderstorm cloud–CG lightning–surface fuels of forest can be combined together, from micro-electrification to macro-statistics, perhaps this kind of heterogeneity can be avoided.

(II)data.

The common data are satellite, radar and conventional meteorological observation, forest ecosystem positioning station, the forestry department of fire statistics, lightning locator, etc.

(III)the aim of study

The terminal goal of lightning-caused forest fire is forest protection. The current prevention and control of lightning-caused forest fire still is the method of fire fighting in all over the world. Our purpose is to prevent, or the circle of ‘lightning-caused forest fire - forest diseases and insect pests and increase carbon dioxide emissions - global warming - the lightning-caused forest-……’ will continue.

**(3)Round table discussions**

Our discussion topic today:

A. lightning-caused forest fire in your location? Codition, method, and other?

B. global warming and lightning-caused forest fire.

C. lightning-caused forest fire in moist area?

In connection with discussion topics, we will assign 1-2 journal articles. You are responsible to study the articles thoroughly before the discussion session and be ready to offer your comments on them and to engage yourself with fellow classmates during the session.

We will devote a session every week to analyze the assigned journal articles. Each session will be led by a student, as designated at the beginning of the semester. The lead student should start the session by answering discussion topics listed above from his/her own perspective, guide the discussion to ensure productivity, and finally, close the session by concluding remarks. Other students should participate in the discussion activity.

# Lecture 5.Forests and water

Forests act as giant sponges, soaking up rainfall during wet seasons and slowly releasing it during times of drought. Forests provide natural filtration and storage systems that supply an estimated 75 percent of usable water globally. Tree roots and leaf litter create conditions that promote the infiltration of rainwater into the soil and then into the groundwater, providing supplies during dry periods.

1. There are a range of estimates for the value of water regulation and supply.
2. Today, at least one third of the world's biggest cities, such as New York, Singapore, Jakarta, Rio de Janeiro, Bogotá, Madrid and Cape Town, draw a significant portion of their drinking water from forested areas.
3. Removing pollutants: Trees and forests improve stream quality and watershed health by decreasing the amount of storm water runoff and pollutants that reach local waters. They take up nutrients and pollutants from soils and water through their roots, and transform them into less harmful substances.
4. Forests also maintain high water quality by minimising soil erosion and reducing sediment. Deforestation generally increases erosion, resulting in higher sediment concentrations in the runoff and siltation of watercourses.
5. Flood protection: The capacity of forests to reduce the incidence and severity of downstream flooding associated with major rainfall events may be more limited than is commonly thought. Nevertheless, maintaining natural vegetation in catchments and riparian zones can reduce flash flooding and flood peaks through the sponge effect of standing forests, and diminish the damaging impacts of local floods by blocking the path of the water with tree trunks, branches and other forest litter.
6. Global significance: Recent research8 highlights the global significance of forests in recycling rainfall and groundwater to support continental-scale and intercontinental-scale hydrological cycles. At these scales, forest loss and degradation appear to have deleterious effects on rainfall.9 These results suggest that forest–water relations at the continental and intercontinental scales are different from those at a catchment scale, where deforestation can increase water yield in the catchment.

Examples of continental-scale impacts: Deforestation and forest degradation in one area can impact rainfall patterns in other parts of the world. Moisture evaporating from the Eurasian continent is responsible for 80 percent of China's water resources. In South America, the Río de la Plata Basin depends on evaporation from the Amazon forest for 70 percent of its water resources. The Congo Basin is a major source of moisture for rainfall in the Sahel.

In Flores, Indonesia, for example, tropical forested watersheds have been shown to increase base flows and reduce the impacts of drought on downstream agrarian communities.

# Lecture 6.Forests and climate change mitigation

Carbon sinks:Forests play a critical role in regulating the Earth’s climate through the carbon cycle; removing carbon from the atmosphere as they grow, and storing carbon in leaves, woody tissue, roots and organic matter in soil.The world’s forests absorb 2.4 billion tone of carbon dioxide each year, or about one-third of the carbon dioxide released through the burning of fossil fuels.

Forests also represent the world’s most significant terrestrial carbon store, containing an estimated 77 percent of all carbon stored in vegetation and 39 percent of all carbon stored in soils; twice as much carbon as is present in the atmosphere.

The loss of peatland and mangrove forests contributes disproportionately to carbon dioxide emissions, biodiversity loss and to the vulnerability of coastal communities, making the conservation of these ecosystems key in the fight against climate change.

Recent research has revealed major capacity gaps in the ability of most tropical forest-rich nations to measure and monitor the amount of greenhouse gas emissions they save by safeguarding their forests.

# Lecture 7.Forests and climate change adaptation

Managing standing forests better, and expanding tree cover through socially- and environmentally-responsible reforestation and restoration, helps deliver a range of livelihood and environmental benefits that assist both people and ecosystems adapt to climate change.The benefits include, but are not limited to, the points listed below.

Safety nets:Forests are important safety nets for communities, helping them cope with climate shocks. Many forest products are more resilient to climate variability and extremes than crops, and so are crucial to the resilience of local livelihoods. They can also consume products – such as mushrooms, sago, fruits and bushmeat – as food. In addition, fodder from trees can help ensure the survival of livestock for months at a time if drought strikes.Trees on farms protect the soil and regulate water and microclimate, and help protect crops and livestock from climate variability. Crops grown in agroforestry systems are more resilient to drought, excess precipitation, and temperature fluctuations and extremes.Forests contribute to regulating river flows – base flows during dry seasons and peak flows during rainfall events – minimising risks related to water scarcity and floods.

Coastal forests such as mangroves help reduce risks from disasters relating to climate extremes (storms or cyclones) and sea-level rise (coastal flooding).

Urban forests and trees provide green infrastructure – shade, evaporative cooling, and rainwater interception, storage and infiltration– in cities. They can play a significant role in urban adaptation to climate variability and changeby reducing temperatures during heat waves.

Tropical forests influence precipitation and can have a cooling effect on a region through increased evaporation and cloud cover.This can occur over large distances: for example, land use change in the humid tropics can influence precipitation in the middle and higher latitudes.

National Adaptation Programmes of Action (NAPAs):The critical role of forests and trees is already recognised in projects on human adaptation, several of which are being proposed in NAPAs. Forest and tree services can also support and increase the effectiveness of technical or infrastructural adaptation measures, while providing co-benefits for livelihoods, biodiversity and climate change mitigation.

**Requesting**

**(1)Oral presentation**

Through discussion, everyone in the class needs to give an oral report independently by means of PPT, the title of your presentation must be limited in the scope of the discussion topic, the time limit is 15 min. Everyone in the classroom can ask questions about your presentation.

Think the oral presentation as part of your job interview. Rehearse beforehand. Come well prepared with any visuals and props, speak clearly and confidently.

**(2)Writing report**

According to your oral presentation, you should write a formal report. To start, you may think your report to be a literature review, which is usually a must for any scientific writing. You should have a general question that you like to answer with your report. Then you should divide the general question into specific questions each of which you can actually answer.

The length of your report is not more than 800 words, its about 1.5 pages of A4.

Grading policy (for everyone)

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| **activity** | **self** |
| **discussion** | 20 |
| **Oral presentation** | 40 |
| **Written report** | 40 |
| **total** | 100 |