Subject: gaussian air dispersion model
Posted by guillaume.drolet.1 on Thu, 24 Nov 2005 16:48:58 GMT
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Hi,

I am using spatial remote sensing data (reflectances over vegetation) along with field eddy-covariance data, i.e. energy and mass fluxes from towers to develop better ways of estimating forest productivity.

For a given period, the vegetated area contributing to the fluxes (footprint) depends on several factors (e.g., wind speed and direction,surface roughness length, etc.) and can be modeled using a footprint model.

To extract the data for the pixels contributing to the measured fluxes, I will use an across-wind integrated footprint model that will give me the across-wind distance (x-extent) of the footprint (i.e., the minor axis of an ellipse). Since I have several periods of flux data for which I need to run the footprint model, I cannot use a fully-parameterized footprint model that would give me the along- and cross-wind extents of the footprint. Thus, I need to use a gaussian dispersion model to estimate the along-wind distance. Knowing both x- and y- extents, I will be able to create ellipses that will serve as my 'ROIs' to extact reflectance data.

Since I do almost all my work with IDL, I am looking for IDL ways of estimating along-wind distances of the footprints using a gaussian dispersion model (functions, procedures, etc.). I don't have a strong background in physics so I need some solutions I will understand. My background is mostly in forest sciences and remote sensing and I do a lot of programming.

Thanks a lot for your help.

Gui

Subject: Re: gaussian air dispersion model
Posted by Mark Hadfield on Tue, 29 Nov 2005 00:04:29 GMT
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guillaume.drolet.1@ulaval.ca wrote:
> [snip]
> The footprint model will give me one dimension: the distance of the
> footprint in the mean wind direction, for a given measurement period
> and a given percentage (r) to be included. This distance will be the
> major-axis of the ellipse. The length of the ellipse's minor-axis (i.e.

> across-wind width) will be missing and this is what I want to estimate
> with a gaussian function. How I will do that, honestly, I don't know???
> This is where I need help.

Then you are probably asking these questions in the wrong forum.

But obviously the hard bit is calculating the width parameter to be used in the Gaussian function. The usual assumption is

sigma-y = sigma-theta * x * f(x)

where x is downwind distance, sigma-theta is standard deviation of wind direction (in radians) and f(x) is a function that equals 1 at short distances and then slowly drops away. If the distances in question are small you can get away with

sigma-y = sigma-theta * x

Do you have any info on sigma-theta?

> As I said before, I need a way to estimate the 'across-wind width',
> knowing the 'along-wind extent' and other variables measured by the
> tower sensors (e.g., mean wind direction (x,y,z), etc.). I don't have a
> clue how I'm gonna find this but one thing is sure, I'm gonna need help!

You're going to need to do a bit of reading.

--
Mark Hadfield "Kei puwaha te tai nei, Hoea tahi tatou"
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National Institute for Water and Atmospheric Research (NIWA)

Subject: Re: gaussian air dispersion model
Posted by guillaume.drolet.1 on Tue, 29 Nov 2005 03:18:36 GMT
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> If the distances in question are
> small you can get away with

> sigma-y = sigma-theta * x

Are distances between 500 and 1500 m considered small?

> Do you have any info on sigma-theta?

Yes. Since the mean wind direction for a 30-minute period comes from high frequency measurements (10 Hz), I should be able to get sigma-theta.

> You're going to need to do a bit of reading

You are right. I definitely need to do some reading and maybe I posted in the wrong forum.

Subject: Re: gaussian air dispersion model
Posted by Mark Hadfield on Tue, 29 Nov 2005 04:00:18 GMT
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guillaume.drolet.1@ulaval.ca wrote:
>> If the distances in question are
>> small you can get away with
>
>
>> sigma-y = sigma-theta * x
>
>
> Are distances between 500 and 1500 m considered small?

Damn, I hoped you weren't going to ask!

I'm reaching way back into my memory banks here. The short answer is that 500 to 1500 m is probably small enough that the above formula will be an overestimate, but good enough to get started with. The long answer is that the distance at which the growth of sigm-y starts to drop away from the linear formula depends on the correlation time scales of the cross-wind turbulent fluctuations. You can estimate the Eulerian time scale from your anemometer. The problem is that what you really want is the time scale for the fluctuations experienced by a Lagrangian particle (ie one moving with the wind) and these will generally be longer. There is a lot of info about this in the literature so you should eventually be able to come up with reasonable values. Right now I suggest you use the linear relation.

> Yes. Since the mean wind direction for a 30-minute period comes from
> high frequency measurements (10 Hz), I should be able to get
> sigma-theta.

Good.

> You are right. I definitely need to do some reading and maybe I posted
> in the wrong forum.

No worries. I just did a quick search on Google Scholar and came up with the following. It's rather old and has an urban focus rather than an agricultural one, but it might help...

Applied dispersion modelling based on meteorological scaling parameters.
Gryning, S E | Holtslag, A A M | Irwin, J S | Sivertsen, B |
Atmospheric Environment. Vol. 21, no. 1, pp. 79-89. 1987

A method for calculating the dispersion of plumes in the atmospheric boundary layer is presented. The method is easy to use on a routine basis. The inputs to the method are fundamental meteorological parameters, which act as distinct scaling parameters for the turbulence. The atmospheric boundary layer is divided into a number of regimens. For each scaling regime the authors suggest models for the dispersion in the vertical direction. The models directly give the crosswind-integrated concentrations at the ground, chi sub(y), for non-buoyant releases from a continuous point source. Generally the vertical concentration profile is proposed to be other than Gaussian. The lateral concentration profile is always assumed to be Gaussian, and models for determining the lateral spread sigma sub(y) are proposed. The method is limited to horizontally homogeneous conditions and travel distances less than 10 km. The method is evaluated against independent tracer experiments over land. The over land. The overall agreement between measurements and predictions is very good and better than that found with the traditional Gaussian plume model.

Descriptors: atmosphere | boundary layers | meteorology | pollutant dispersion; mathematical models | atmospheric conditions |

--
Mark Hadfield "Kei puwaha te tai nei, Hoea tahi tatou"
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National Institute for Water and Atmospheric Research (NIWA)

Subject: Re: gaussian air dispersion model
Posted by David Fanning on Tue, 29 Nov 2005 04:28:10 GMT
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Mark Hadfield writes:

> Descriptors: atmosphere | boundary layers | meteorology | pollutant
> dispersion; mathematical models | atmospheric conditions |

Don't you have any work to do, Mark?

Cheers,

David
--
David Fanning, Ph.D.
Fanning Software Consulting, Inc.
Coyote's Guide to IDL Programming: http://www.dfanning.com/

Subject: Re: gaussian air dispersion model
Posted by K. Bowman on Tue, 29 Nov 2005 14:27:32 GMT
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In article <MPG.1df586c47a3e3b0d989ac6@news.frii.com>,
 David Fanning <davidf@dfanning.com> wrote:

> Mark Hadfield writes:
>
>> Descriptors: atmosphere | boundary layers | meteorology | pollutant
>> dispersion; mathematical models | atmospheric conditions |
>
> Don't you have any work to do, Mark?
>
> Cheers,
>
> David

I did say that I thought this would be at least moderately complicated, but I'm glad he found a collaborator. ;-)

Ken Bowman

Subject: Re: gaussian air dispersion model
Posted by guillaume.drolet.1 on Tue, 29 Nov 2005 14:56:24 GMT
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> No worries. I just did a quick search on Google Scholar and came up with
> the following. It's rather old and has an urban focus rather than an
> agricultural one, but it might help...

Thanks Mark. I found the paper you suggested. I'll keep you informed.
