**Biogeosciences
Discussions**

Interactive comment on "Satellites reveal an increase in gross primary production in a greenlandic high arctic fen 1992–2008" *by* T. Tagesson et al.

Anonymous Referee #2

Received and published: 17 April 2010

GENERAL COMMENTS:

I.) The manuscript of Tagesson et al. deals with an important topic of arctic ecosystem science. The question how the arctic vegetation will respond to changes in climate and atmospheric CO2 concentrations is crucial for the assessment of the current and future carbon source/sink function of the sensitive tundra landscapes. As the carbon pool in these permafrost-affected ecosystems is very large, changes of the carbon exchange processes here can have significant effects on the global atmospheric carbon budget and the climate system. The goal of the manuscript to combine the "greening" information from satellite imagery with ground-based measurements of GPP would be an

important step to quantify the changes of the tundra carbon balance on the inter-annual to decadal scale. The topic of the manuscript would fit well into the general scope of BG.

II.) However, I cannot recommend the manuscript for publication due to some major shortcomings. The main problem is that in my opinion the presented approach and data is not sufficient to derive a robust relationship between the satellite information and the ground-based GPP. The authors do not write very clearly about the experimental design, i.e. the number of closed chamber measurements of NEE, Reco and GPP over the day performed on the 11 measurement days. However, according to the df in Table 2, it appears that every plot was measured only once per day. I doubt that it is feasible to calculate a robust mean by averaging only 11 measurements performed on different days with probably different meteorological conditions and different phenological states at different hours of the day. As the CO2 exchange at vegetated sites is characterised by a pronounced temporal variability, the likewise strongly varying environmental control variables (e.g., irradiance) must be accounted for which is typically done by developing empirical models which explain GPP in dependence of PAR, temperature and possibly other influencing variables and allow the modelling of CO2 exchange fluxes over time by using continuous datasets of control variables. The parameters of the models can be compared between vegetation types or be used to calculate weekly, daily or mean hourly GPP. Such GPP data would be more appropriate to be related to FAPAR or NDVI information for upscaling in space and time than the means of 11 chamber measurements used in the manuscript. The presented means of GPP (Table 2) represent an average over the diurnal, seasonal, weather-related, and spatial variability, and it is quite unlikely that this average of 11 data point will represent the "true" mean GPP of the plots during the peak growing season. Furthermore, it should be noted that just taking averages from chamber measurements introduces a significant underestimation bias to GPP estimates as PAR is always lower in the chamber compared to ambient, and this difference in PAR has to be accounted for by some model approach. The here discussed shortcomings are probably reflected in the poor

validation skill of the model which can be seen in Figure 3. Although LUE-based and modelled GPP was highly correlated, this does not mean that the model skill is good. The Pearsson correlation coefficient is a not very efficient statistical indicator in this context. When evaluating potential biases, the slope and intercept of a regression line would have been more meaningful. I do not agree with the authors that the model only slightly overestimated GPP. About 30% deviation is a rather significant bias. Also, the model has strongly differing performances for the three validation years. Actually the shown data suggest that there might be different NDVI-GPP relationships (different slopes and intercepts) for 1998 and 2007 compared to 2000 which is not a good sign for model stability. In my view, the manuscript presents valuable information about the greening at this high arctic site but fails to improve the quantitative assessment of the effect of the greening on the GPP.

III.) The closed-chamber approach to determine GPP is not described in sufficient detail. What was the chamber height? What was the collar area? What was the material of the transparent chamber walls? Did the chamber have a vent or not? What was the CO_2 concentration measurement interval? Was the chamber headspace air cooled? Was the temperature increase inside the chamber monitored? Without these information, it is not possible to assess the probability of biases introduced by the applied chamber methodology.

IV.) Combining an empirical linear model connecting small-scale FAPAR with larger scale NDVI with an empirical model connecting FAPAR with GPP clearly demands a thorough uncertainty analysis to be able to evaluate the extrapolation results. However, such an uncertainty analysis was not provided at all.

V.) The language of the manuscript is not appropriate for publication at this point. I had to make quite many orthography comments; particularly concerning the correct placing of commas. Also the grammar and style has to be improved. Often, the wording is not precise enough for a scientific text. One example: page 1110, line 8: "using nearest neighbour, ..." This is colloquial language; in a scientific text the full term should be

used: "nearest-neighbour interpolation" or "nearest neighbour algorithm". I suggest that the authors go carefully through the long list of technical comments. Very likely, I have not found all mistakes. Also, the structure and clearness of the whole manuscript has to be improved. In my opinion, the authors should have proof-read this manuscript much more carefully before submitting it to a journal.

VI.) Considering the major shortcomings of the manuscript, I recommend the rejection of this manuscript.

SPECIFIC COMMENTS.

1.) page 1102, line 13: Specify. On which spatial scale the GPP was modelled? Monthly GPP, annual GPP, average daytime GPP at the peak of the growing season?

2.) Page 1102, lines 13-14: Here you should make a statement on the model performance (which was not so great in my opinion).

3.) Page 1102, line 16: "well correlated" is not sufficient when evaluating possible biases.

4.) Page 1104, lines 9-10: Give already here an indication how LUE was "parameterised"?

5.) Page 1104, lines 11-12: For the extrapolation approach, the correlation is not essential. It is the identification of the transfer function between NDVI and FAPAR. How this transfer function identification was done can be critical: OLS regression RMA regression? Errors-in-variables models? Both variables are noisy, and OLS regression may not be appropriate.

6.) Page 1105, line 25: Write more specific. Is rho(NIR) is "reflectance in the near infrared (NIR) band)

7.) Page 1105, line 27 to Page 1106, line 1: This sentence is unclear, please rewrite.

8.) Page 1106, lines 6-19: This paragraph about FIPAR and FAPAR is confusing for

me. I would define FIPAR and FAPAR the other way round compared to the authors. To estimate FAPAR, you only need the incoming and the reflected PAR: FAPAR = (Incoming PAR – reflected PAR) / (incoming PAR). However, this is the equation which is used for the calculation of FIPAR in the manuscript (?!). I think that FIPAR = fraction of ground covered by photosynthetically active vegetation * FAPAR. In the manuscript it is the other way round. The fraction of absorbed radiation must always be higher than the fraction of radiation intercepted by the vegetation. Apparently, the authors have related FIPAR to NDVI and not FAPAR to NDVI as was intended to do. This should have a disturbing effect on the results if the vegetation cover is significantly less than 100%.

9.) Page 1106, lines 18-19: please indicate the threshold values of illumination angles which corresponds to these exclusion times.

10.) Page 1107, line 3-4: As both NDVI and FAPAR are noisy variables, the transfer function could be biased. What happens if you take FAPAR as the explanatory x-variable and NDVI as the explained variable y ? The result for the transfer function between NDVI and FAPAR will be different. This potential bias has to be kept in mind for the uncertainty assessment.

11.) Page 1107, lines 16-17: How often one plot was measured on one measurement day? See also GENERAL COMMENTS above.

12.) Page 1108, lines 17-18: What were the percentiles defining the region where data points were considered to be outliers? Actually, I think that such an outlier exclusion is not appropriate when dealing with highly variable time series! Outliers cannot defined just in relation to the mean of all points!

13.) Page 1108, lines 20-21: Taking the mean of only 3 of the only 11 measurement points in time is even more dangerous than taking the mean of 11 points. This approach is very questionable, please see paragraph II in General Comments

14.) Page 1108, lines 20-26: See above: FIPAR and FAPAR were confused!

15.) Page 1109, line 15: How many days? +/- 7 shall indicate the uncertainty of this time span, right? But how long was the time span itself?

16.) Page 1110, lines 1-2: What is the correction exactly for?

17.) Page 1111, lines 13-15: Pearssons's correlation is not the appropriate measure to evaluate biases. Slope and regression of regression lines would be more interesting.

18.) Page 1111, lines 18-20: R^2 is of course significant. For an uncertainty analysis, one should have a look on the uncertainty of the parameters of the linear functions. It should also be considered that there could be a bias due to inappropriate use of OLS regression when x is noisy.

19.) Page 1112, line 24: "soil temperature in 10 cm depth"

20.) Page 1113, line 15: This is no slight overestimation but a significant overestimation (30%).

21.) Page 1114, lines 9-10: It does not become really clear what the GPP values are actually standing for: Average GPP over daytime (10 a.m.-6 p.m.) during the peak of the growing season?

22.) Page 1115, lines 9-17: Why did the earlier study found the opposite trend? Do you have an explanation for this discrepancy? Different sites?

23.) Page 1116, lines 1-3: it is not possible to compare daily GPP values with GPP values restricted to some hours during the daytime. This is no issue which has to be discussed in the discussion. You can only compare your GPP data with other published daytime data.

24.) Page 1116, lines 21-24: This is not only a possible explanation, this is a fact. And this bias has to be accounted for by using empirical models between GPP and PAR.

25.) Page 1117, line 13-15. Pearsson's correlation coefficient is not appropriate to evaluate biases. In my opinion, the model showed in this validation test not a good

skill. As also no uncertainty analysis was provided, it remains highly unclear how much we could trust the spatial and temporal up-scaling by the presented approach (see also Genreal comments II.).

TECHNICAL COMMENTS.

26.) page 1102, line 10: hyphenate: "field measured"

27.) page 1102, line 11: "was" instead of "were"

28.) page 1102, line 14: Insert comma before "and".

29.) Page 1102, line 16: Insert comma before "and".

30.) Page 1102, line 16: Insert something like "According to the results of this study,. . ." or "The results of this study suggest. . ..2

31.) Page 1102, line 18: Move "during this period" to the end of the sentence.

32.) Page 1102, line 20: Remove comma before "due".

33.) Page 1102, line 22: Hyphenate: "High-latitude"

34.) Page 1102, line 26: Remove comma before "since"

35.) Page 1102, line 26: Insert "soil": "cool soil conditions"

36.) Page 1103, line 1: Write more specific ". . .the rates of soil organic matter decom-position, . . ."

37.) Page 1103, line 6 : uptake and release of what? Write specific.

38.) Page 1103, line 7: "carbon sink" instead of only "sink"; "of" instead of "for"

39.) Page 1103, line 9: Write more specific: "remote sensing data form satellites" instead of only "satellites".

40.) Page 1103, line 14: Insert comma before "and very"; "however" instead of "and".

C599

41.) Page 1103, line 15: comma before "high"

42.) Page 1103, line 18: More precise: "plant productivity"

43.) Page 1103, line 26: comma before "and"

44.) Page 1104, line 7: sentence structure awkward

45.) Page 1105, line 15: Hyphenate: "Non-vegetated"

46.) Page 1106, line 7: Remove comma before "and".

47.) Page 1106, line 27: Insert comma before "and".

48.) Page 1106, line more precise: "using the spectral information of a Landsat. . .."

49.) Page 1107, line 12: Insert comma after "plots".

50.) Page 1107, line 18: "chamber volume" instead of "chamber"

51.) Page 1107, line 19: Insert comma before "and"

52.) Page 1107, line 21: insert comma before "two"

53.) Page 1107, line 24-25: Revise sentence structure.

54.) Page 1108, line 16: "exchange fluxes " instead of "effluxes"

55.) Page 1109, line 15: Remove comma before "that"

56.) Page 1110, line 8: "nearest neighbour interpolation", insert "the " before "average"

57.) Page 1110, line 12: Insert comma before "and"

58.) Page 1110, line 23: Remove comma before "since"

59.) Page 1111, lines 4-7: If 1999 was not used, it is noz needed to write about it.

60.) Page 1111, line21: Remove "at"

61.) Page 112, line 6: "values" instead of "value"

62.) Page 1112, line 14: Remove comma after "Although"

63.) Page 1112, line 15: Insert comma before "it".

64.) Page 1112, lines 19-22: Awkward sentence, please revise.

65.) Page 1112, line 22: Insert comma before "there"

66.) Page 1112, line 27: Revise sentence structure.

67.) Page 1113, line 5: insert comma before "and"

68.) Page 1113, line 7: insert comma after "variation"

69.) Page 1113, line 21: remove "up"

70.) Page 1114, lines 2-6: This should be written more scientifically.

71.) Page 1114, line 13: Insert comma after "temperatures"

72.) Page 1114, line 14: Hyphenate: "temperature-limited"

73.) Page 1114, line 17: Insert comma before "and"

74.) Page 1114, line 20: Insert comma before "and"

75.) Page 1114, line 23: Hyphenate: "warming-induced"

76.) Page 1114, line 24: "decomposition of soil organic matter"

77.) Page 1114, line 25: Hyphenate: "nutrient-limited", change to "leading to a scarce plant cover.

78.) Page 1115, line 9: Remove "up"

79.) Page 1117, line 4: Insert comma after "period"

80.) Page 1117, line 5: Hyphenate: "global change-induced"

81.) Page 1117, lines 7-8: Insert comma before "and"

82.) Page 1117, lines 11-13: Hyphenate: "high-arctic" (2x)

83.) Page 1117, lines 16-17: Insert comma before "and"