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February, 28<sup>th</sup> 2013

Dear Prof. Geraint Vaughan and the anonymous reviewer,

Authors response to the comments of the referee,

The authors thank the anonymous referee for his comments which did contribute to improve the manuscript.

Note that in the following text, the comments of the referee are written in dark blue italic and our replies in regular font (in black).

***Referee #2 comments (comments received and published: 20 December 2012):***

*Overview The paper*

*"Preliminary signs of the initiation of deep convection by GNSS" by Brenot et al. Studies ZTD gradients from a network of GNSS receivers over Belgium with the goal of improving near real-time forecasting of convective initiation. This study is definitely worth pursuing with regards convective initiation and nowcasting, however there are a number of problems with the methodology and with the scientific language used in this paper which must be addressed prior to publication.*

*Major Comments to the Authors There is a lack of quantification throughout the paper and the reader has to depend on vaguely expressed qualitative terms e.g. humidity and instability – these need to be quantified in terms of relative humidity, water vapour or CAPE or something else. Additionally there are a number of non-scientific terms used in*

*the paper such as 'water vapour bubbles' and 'neutrosphere' which should be replaced with more accepted scientific terminology.*

*There is no assessment of error with respect to decreasing the observation time interval for calculating ZTD or gradients, that is, how much error is introduced in ZTD and gradient values with 15 minute data intervals as opposed to longer intervals (or smaller intervals, e.g., 5 minutes)? This, I suppose, will become even more important when using real time predicted orbits. And, as mentioned above, the error associated with real time predicted orbits needs to be estimated.*

*Due to the fact that this study was done in a post-processing fashion, in its current state it has little real relevance to nowcasting. The study needs to be conducted again using IGU products (predicted half of the IGS Ultra rapid products) which would give a true reflection of the products which could be derived for near real-time applications. One idea would be to study how much worse the ZTDs and ZTD gradients are using IGU products vs. IGS Final products.*

*More information needs to be given with regards to calculating the ZTD gradients – this is not entirely clear. Also, the orbits used for calculation should've been mentioned earlier in the paper.*

*From the paper it is clear to me that the gradients add little to the overall study and it is the convergence of water vapour fields (as observed in the ZTD) which are of most benefit to predicting convective initiation. As such I would propose looking at the data again and only looking at ZTD or IWV fields and their flux as precursors. Ideally the advected component due to winds would be removed so you are only measuring the ZTD/IWV change in the same parcel of air, and not just if a parcel of air with higher ZTD has been transported into the cone of observation*

REPLY AUTHORS:

We have tried to do our best to correct the problems with the methodology and with the scientific language in the REPLIES to the comments of the Referee #1 (see notably REPLY AUTHORS 5, 19 and 21). Considering the use of rapid orbit and fast calculations (see REPLY AUTHORS 50).

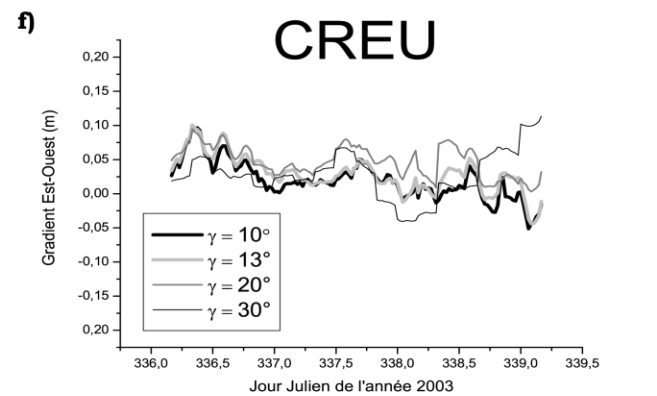
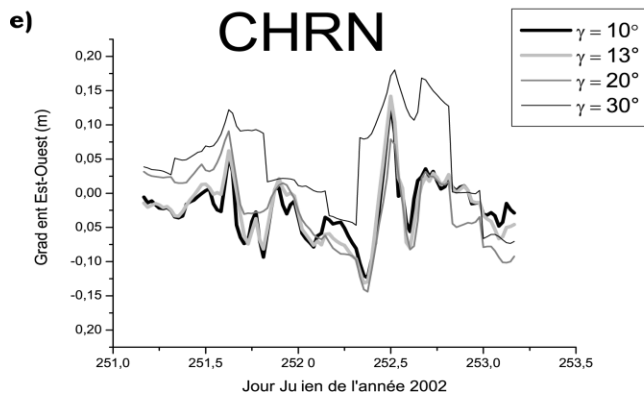
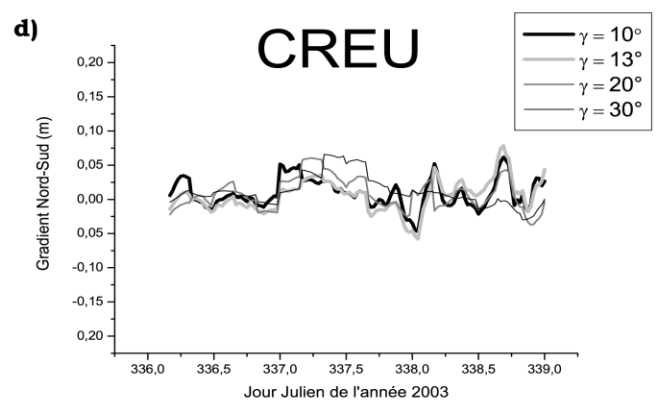
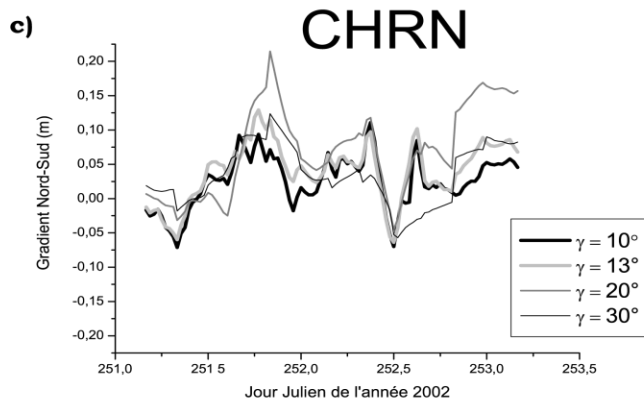
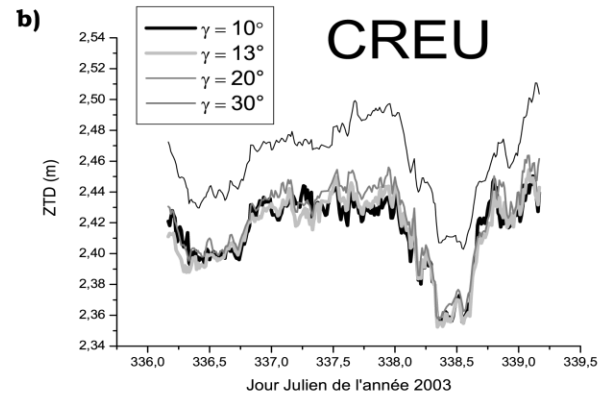
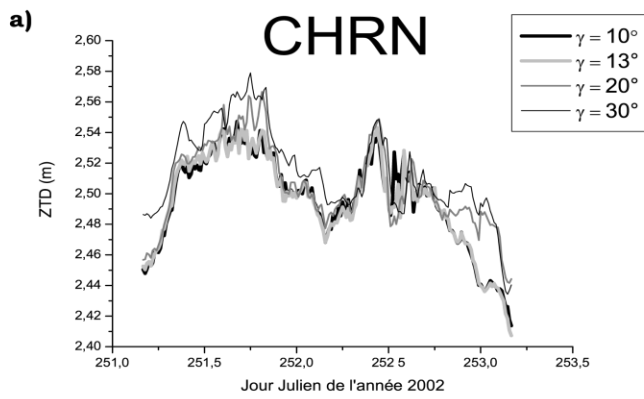
### Specific Comments and Technical Issues

*P. 20352*

*Line 12. If the baselines were 5-30km maybe a higher elevation cut-off should've been used so that the observations were more from overhead*

REPLY AUTHORS:

We don't think the use of a high cut-off angle is a good idea. Have look on these figures:



For two rainfall event in South-East of France, ZTD and gradients have been calculated with a range of cut-off from 10° to 30° (only 4 cut-off angles are shown on these figures: 10°, 13°, 20° and 30°). The conclusion is the following: there is no interest to use a high cut-off angle (30° for example). Even ZTD obtained with a cut-off of 20° and 25° are not absurd, estimations of ZTD with a cut-off of 30° look wrong. For the gradients, a cut-off between 10° and 15° shows more stable values. A cut-off over 20° show bad estimations of gradients. For high cut-off angle, the positioning solution adjusted in the same time than the ZTD and gradient is wrong, especially for the vertical position.

*Line 20 Define 'mean' meteorological observation*

REPLY AUTHORS:

See REPLY AUTHORS 26 to the comments of the Referee #1

*Lines 21. "first order" and "second order" need to be defined – expand.*

REPLY AUTHORS:

See REPLY AUTHORS 27 to the comments of the Referee #1.

*P. 20353*

*Line 5. Change 'forerunners' to a more meteorological term Line 7.*

REPLY AUTHORS:

See REPLY AUTHORS 28 to the comments of the Referee #1.

*Change 'GNSS gradients of delay' to 'GNSS delay gradients'*

REPLY AUTHORS:

OK text modified in all the paper.

*P. 20354*

*Line 1. Change 'wet' and 'invaded' to more descriptive terms*

REPLY AUTHORS:

See REPLY AUTHORS 10 to the comments of the Referee #1.

*Line 9. Define 'clusters'*

REPLY AUTHORS:

See REPLY AUTHORS 15 to the comments of the Referee #1.

*Line 14. Change 'downpours' to maybe 'heavy precipitation'*

REPLY AUTHORS:

OK change done.

*Line 17. Need to give more information about ALADIN NWP model*

REPLY AUTHORS:

See REPLY AUTHORS 3 and 34 to the comments of the Referee #1.

*Line 22. Change 'GNSS has been used to characterise the humidity field' to 'GNSS networks have been used to characterise horizontal humidity fields'*

REPLY AUTHORS (change of the text line 22):

GNSS networks have been used to characterise horizontal water vapour content fields of the troposphere.

*P. 20355*

*Line 8. Change 'MET' to 'meteorological' if that's what is meant here. This whole sentence is a little vague and should be reworded.*

REPLY AUTHORS:

Section 3.1 modified, see REPLY AUTHORS 18 to the comments of the Referee #1.

*Lines 16-18. This needs to be clarified – more information on processing method is needed Line 23. 'Bi-frequencial' should be changed to 'dual frequency'*

REPLY AUTHORS:

OK, Section 3.1 modified, see REPLY AUTHORS 18 and 19 to the comments of the Referee #1.

*P. 20356*

*Line 14. 'amplitude 2 times over mean amplitude' is a bit confusing – needs to be clarified*

REPLY AUTHORS:

OK, Section 3.1 modified, see REPLY AUTHORS 18 and 19 to the comments of the Referee #1.

*Line 20. 'neutrosphere' should be changed to 'neutral atmosphere'*

REPLY AUTHORS:

OK, that has been changed in the text and in the figures.

P. 20357

*Line 9. 'water vapour bubbles' should be changed to a more meteorological term Lines 24+35*

REPLY AUTHORS:

OK Blobs has been used, see REPLY AUTHORS 39 to the comments of the Referee #1.

*with such a dense GNSS network in Belgium, maybe a higher elevation cut-off angle could've been used so observations were more overhead*

REPLY AUTHORS:

No, as shown in the previous figure.

P. 20358

*Line 5. 'are equivalent to the humidity field' – not true, they are 'proportional to' maybe...*

REPLY AUTHORS:

Thanks for this comment. The text has been modified, see REPLY AUTHORS 41 to the comments of the Referee #1..

*Line 22 'strong activity' this needs to be defined with intense precipitations comment about gradients strong flux ... asciated to low level converge (large intensity)*

REPLY AUTHORS (See REPLY AUTHORS 3 + modification of text in this section):

Amount of hourly precipitation has been quantified in the draft (up to 55 mm/hour, with a daily precipitation up to 95 mm/day), for the gradient (amplitude up to 0.045 m, which means up to 0.25 m at 10° of elevation). High observations observed between 12H and 15H UTC, the 29<sup>th</sup> June 2005.

P. 20359

*Line 10. What is meant by Digital Counts? This needs to be defined or replaced with another more common term*

REPLY AUTHORS:

See REPLY AUTHORS 42 to the comments of the Referee #1.

*Line 14 – suggest to remove 'the weather office of' – not needed, sentence is fine without it*

REPLY AUTHORS:

Ok we did.

*Line 21 – again DC is referred to, same comment as above.*

REPLY AUTHORS:

See REPLY AUTHORS 42 to the comments of the Referee #1.

*P. 20360*

*Line 15. 'bubble of humidity' should be replaced with a more meteorological term*

OK Blobs has been used, see REPLY AUTHORS 39 to the comments of the Referee #1.

*Line 16 – 'dipole' maybe changed to 'gradient'?*

REPLY AUTHORS:

To avoid a confusion for the reader of gradient (instead of dipole) with GNSS gradient, we modify the text p. 20360, lines 14-16 and put a definition of the word dipole that we will use farther in the paper:

To the east of the NAMR region, a blob of water vapour was identified. Then, a dry-wet contrast between the wet region and the drier nearby region can be observed. Further on in this study, we will call this dry-wet contrast, which can take place in space and time, a "dry-wet dipole".

*Line 21 Cloud formation is a sink of humidity, humidity does not increase with cloud formation. Sentence needs rewording*

REPLY AUTHORS:

See REPLY AUTHORS 44 to the comments of the Referee #1.

*P. 20362 Line 4. 'humidity' and 'instability' need to be defined in terms of relative humidity or water vapour and/or CAPE etc*

REPLY AUTHORS:

See REPLY AUTHORS 3 and 45 to the comments of the Referee #1.

*P. 20363*

*Line 4. 'neutrosphere' should be replaced with 'neutral atmosphere'*

REPLY AUTHORS:

OK, that has been changed in the text and in the figures.

*Line 23. 'GNSS delay variations are driven by humidity variations and integrated water vapour' – these are essentially the same thing are they not ?*

REPLY AUTHORS (text line 23 modified):

Note that GNSS delay variations are driven by integrated water vapour (IWW) content variations.

*P. 20364*

*Line 1 'substantial decrease of ZTD followed by a strong increase of ZTD' – this needs to be defined – by how much? What are the criteria used for an alert?*

REPLY AUTHORS (text line 1 modified):

H<sub>2</sub>O alerts based on a substantial decrease of ZTD (at least 8 mm) followed by a strong increase of ZTD (at least 15 mm) over two time periods each of 15 minutes (the total process lasts 30 minutes).

*Line 17. ZTD gradients have not added anything to detecting convective initiation, it is ZTD flux/differences which have given this information*

REPLY AUTHORS:

See REPLY AUTHORS 21 to 25 to the comments of the Referee #1.

Thank you for your comment and advice which helps.

Yours faithfully,

Hugues Brenot

