General comments

This paper adds one piece to the important puzzle regarding the variability of the subpolar gyre. The result that the subpolar gyre circulation can be brought to a threshold position, where is becomes highly sensitive to freshwater and wind stress forcing, is very interesting. And if this holds true, it might improve our ability to predict the marine climate and ecosystems in the subpolar Atlantic. The result that it is freshwater forcing over the Nordic Seas that regulates this threshold is both puzzling and interesting.

But the paper appears rather unfinished to me. The linkage between the freshwater forcing over the Nordic Seas and the SPG, and the internal feedback loops in the North Atlantic do, unfortunately, not make clear sense to me. Maybe this becomes clearer after the questions below are answered.

Specific comments

The freshwater forcing over the Nordic Seas regulates the threshold SPG variability. It is mentioned that causality go via the overflows, but this is all. The discussed baroclinic changes in the SPG occur within the upper 1000m, while the overflows flow deeper than this. So how can changes in the overflow strength induce the described changes in the SPG? Please describe.

P 264, L 21: In this paper, it said that the NAC and the subarctic front shift southeastward and the paper by Bersch is cited. Care should be taken here. Bersch, Hatun et al, 2005 and others show that the NAC actually shifts north in the Newfoundland Basin- Mid-Atlantic ridge area, during periods when the SPG is strong. Please confer with the literature once more, and clarify accordingly

P 265, L16-19: I do not understand loop 3. It is said that an increased SPG leads to a longer pathway spiraling around and into the gyre. This shall lead to more heat loss, a cooler gyre center and thus a stronger center-rim temperature difference (stronger baroclinicity). 1) How is the rim defined? One should expect that a long stretch along the ‘rim’ would also be colder, and the temperature difference between the center and rim would thus be unaltered. Please explain.

Loop 1 and 2 rely on a fact that a strong SPG induces increased temperatures and salinities in the NE Atlantic/rim or in the Sub polar Mode Water (SPMW). On decadal time scales, it has been shown that a strong SPG is associated with lower temperature and salinities in the SPMW (due to less influence of the warm and saline eastern waters)(e.g. Hatun et al, 2005). Is there a question of time scales here? Please bring this into your discussion.

The gyre becomes unstable when a freshwater anomaly of 15 mSv is added

It is not obviously clear to me how to interpret this

What average is this anomaly relative to? How would the authors know what the right 1000-years average is, and thus what importance should be ascribed to the number ‘15’. Is it important that there is threshold off-set or is number ‘15’ important?

Technical corrections

P 260

L 11 -> freshwater forcing of varying, but small amplitudes and multidecadal to centennial periodicities

L 19 Might consider to used the name Arctic Mediterranean instead of the Nordic Seas, since deep water formation is also formed outside the Nordic Seas.

L20 Over the GSR

L23 Introduced the AMOC abbreviation here and add a reference

L26 The strength

P261

L1 Add ref to the wind stress var.

L2 …Atlantic…

L5 Use fewer refs

L9 …the variations…

L12 Use fewer refs

L14 The Hakkinen et al. Ref is not the right one when referring to the salinity increase. Better ones are for example Curry and Mauritzen, 2005 or Hatun et al, 2005. And this salinity increase started in the mid-1995, and not in 2001.

L16 observations. reduction -> decline a SPG circulation strength

L22 these -> such

L26 time scales

P262

L6 140 yrs

L9-13 Improve sentence

L29 the model, the experiments

L22 By analyzing the…

L23 loops that potentially lead…

L26 define distance

P263

L13 sinusoidal

L14 forcing of (1) -> forcing of surface freshwater

L16 applied within the Nordic Seas (63.75-78.75, 11.25W-10E).

L17 gyre -> SPG (there are gyre within the Nordic Seas as well)

L18 Nordic Seas and thus weakening overflow.

L22-27 The description from L12 and forward seems to be reiterated here (although with more detail). What about just using just one (detailed) version of experiment description?

L25 200 yrs. A general comment is to write 'yrs' and not 'yr' when referring to several years.

L26 Spell out NCEP-NCAR

P264

L1 … are continued by their time-reversed…

L3 presently sounds like yesterday. Use other term. Remove 'to be able to'

P 265

L1 remove 'together' tropical NAC -> the warmer NAC waters

L3 refer to Fig. 2g

L23 late 1990s -> mid-1990s

L25 AMOC introduced before

L25-26 weaker… Than what?

L26-28 Unclear sentence

P 266

L12 sea surface height obs

L14 25% of what?

L14 the previous chapter -> chapter 3.

L22 the SPG

L27 The Variability

Chapter 4 is generally confusing. Please write this chapter clearer

P 267

L25 Add reference

P268

L4 similar processes… Please be more specific here

L14-17 … Than what. Please improve sentence

Fig. 1

Write *weak state* in red (warm) and *strong state* in blue (cold).

Add Sv and mSv to the axes in the inset as well.

Caption: 15 mSv freshwater forcing

Fig. 2

Add units to the colorbars, add ‘m’ to depth axis, add ‘longitude’ and ‘latitude’ to geographical axes. Panel h is too crowded and unclear

Better emphasis on the gray rectangle

Fig. 3

Cooler temperature -> lower temperature

Fig. 4

It took me quite some time to decipher this figure + text. What are ‘the upper two panels’ and ‘the two panels below’? Please refer clearer to the figure.

Fig. 5

Add yrs to the figures (e.g. T = 50 yrs).

Maybe use the same SPG amplitude scale in all panels. This would better show that the wind stress forcing is inferior to the freshwater forcing