

Review of the paper "Reconstruction and simulation of an extreme flood event in the Lago Maggiore catchment in 1868", by P. Stucki et al.

General comments

This paper describes a disastrous hydro-meteorological event that affected Switzerland 150 years ago. Thanks to the availability of the "Twentieth Century Reanalysis" dataset, meteorological and hydrological state-of-the-art models have been applied, to try to obtain quantitative results that complement the documentary/historical data available.

The approach is interesting, and this is probably the earliest event that has been reconstructed/simulated with models, comparing the model results with the earlier observations. The paper is well written and, in my opinion, basically it is worth of publication in NESS. However, I am a bit concerned with the fact that the reanalysis at that time is based on very scarce data (essentially sporadic surface observations) if compared to nowadays situation, so that it is affected by large uncertainties (particularly at small scales and in atmospheric moisture content) that may adversely reflect on the simulations, especially those at high resolution. The latter can be useful since they provide more accurate description of the orography and land properties and of the atmospheric dynamics, but one cannot rely too much upon detailed results of the model simulations: this limited predictability problem at the convective scale severely affects the quantitative precipitation forecasts even in our days. I can only imagine how severe it is at the time of the event! Therefore, I think that the authors should devote more space to try to quantify or at least describe qualitatively if not quantitatively the uncertainties of their results.

Punctual comments

The Introduction appears a bit too long and detailed – it contains some treatment that should be postponed to the specific chapters.

Page 1, line 36: if AS stands for Central Alps, it should be CA. But in the context of the paper I had the suspect that it means "Southern Alps" (or Alps South?). I suggest, in any case, to use initials that correspond to the English terms.

Page 2, lines 1-7: the paper Malguzzi et al (2006) (see also below "References") should be referenced here, with some short description, because it is very similar to the present paper in various aspects: it describes a major historical (1966) flood event that affected the (Eastern) Alps (and not only – it was considered the century flood in Italy). It applies a very similar approach (meteorological and hydrological model chain), although the used reanalysis (and also the verification) takes advantage from a much better data coverage than available one century before!

Page 2, line 9: LMR: Lago Maggiore Region?

Pages 2-3: somewhere in the Introduction (and not only at page 12), the MAP international project must be mentioned (for example quoting Bougeault et al, 2001): its major objective was to study (from the observational and modelling point of view) the atmospheric processes related to heavy precipitation and flood the Alps, with its largest observational effort concentrated just in the Lago Maggiore area.

Page 3, lines 5-18: regarding the PV streamers west of the Alps, I think that the main interesting aspect (related to the orographic forcing) is that the (orographic) precipitation occurs more to the east, with respect to the position of the PV anomaly, than expected in the case of flat terrain. In other terms and using more traditional synoptic concepts, while in the flat case precipitation has to be expected ahead of the cold front, more or less in the area of the warm conveyor belt, in the case of the Alps (or similar orography perpendicular to the more-or-less southerly flow) precipitation may be heavy also in the warm sector well in advance of the cold front. It must be remembered, in any case, that the orography can change the synoptic scale flow at scales larger than those of the orography itself.

Page 4, lines 19-25: please give some more info here about the 20CR for those not familiar, in particular for what concerns the input observations (other variables besides surface pressure? T and humidity?), the available variables on the pressure surfaces and at the ground) and the degree of uncertainty as estimated in the literature.

Page 5, lines 5-8: the application of the nudging, although justified by the need of constraining the forward meteorological model to run close to the reanalysis "trajectory", has drawbacks that should be mentioned: for example, this is not a real "hindcast" experiment – how the precipitation forecast differs from a pure forward integration, i.e. without nudging? (one test should be made at least for one case).

Page 5, lines 21-25: please explain better the procedure – include some words about the quality/limitations/uncertainties of the E-OBS dataset.

Page 6, lines 15-17: there is similarity with the 1966 event described in Malguzzi et al: in both cases there is strong enough precipitation at the divide and on the downstream side of the Alps to cause flooding also of the rivers flowing on the north side. It is not clear, however, to what extent such precipitation "originates" on the upstream side (due to transport of cloud condensates and hydrometeors across the Alpine crest) or on the downstream side (including possible thunderstorms). Model results (see Fig. 8) do not seem to represent this aspect.

Page 6, line 24: it is not clear if only the "inflation" of the Swiss Franc is considered here or also the fact that the nowadays (economic) damages would be much larger due to the real value and vulnerability of today's infrastructures, resources etc. It seems to me the first is the case here, but the second would be more interesting...

Page 8, lines 11-14: I think that the most dramatic aspect, which makes this event so exceptional, is the occurrence of an entire sequence of heavy precipitation cases. Of course, this aspect cannot be "explained" in terms of atmospheric dynamics, even with the help of model simulations.

Page 8, line 37 (and elsewhere, for ex. page 9, lines 25-26): the expression "Rossby wave breaking" is used several times, but I think that not only it is too technical, it is also ambiguous and should deserve an explanation in more traditional terms.

Page 9, lines 2 and 15; page 10 line 1: a blocking anticyclone (in the traditional meteorological literature) is something different (in brief, an anticyclone located at lat. 50-70 over the Atlantic, Pacific or northern Europe, deviating the westerlies for several days). A ridge downstream of a trough is (I believe) a component of the same Rossby wave, that can become almost stationary. So I think that it not very correct to say that the ridge blocks the easterly propagation of the system.

Page 9, line 14: I guess "high-PV", not "low-PV".

Page 9 line 17: perhaps an "atmospheric river"?

Page 9, lines 27-33: qualitatively similar results have been obtained from trajectory computations by Bertò et al, 2004 (among others), for similar events of heavy precipitation on the southern side of the Alps. I suggest to quote this paper (see below the full reference).

Page 9, lines 36-37: I do not think there is a "plausible explanation" – after all, it is not given here.

Page 10, lines 5-8: some more clear should be provided here (or above) about the uncertainties of 20CR.

Section 3.4 is a bit too speculative, given the uncertainties as mentioned above (see the major comments). If uncertainties affect the low resolution, they can only be larger at higher resolution.

Page 10, lines 31 and 33: "well2 and "very good" seem too optimistic, at least in absolute terms (for both amount and spatial distribution of precipitation). I agree that the simulation provide useful meteorological information, perhaps better than expected, but I would use the word "satisfactory" rather than "very good".

Page 11, lines 7-9: these aspects were investigated during the MAP field experiment (as mentioned below). Here I would quote the paper by Rotunno and Ferretti (2001), providing an interesting explanation of the enhanced convergence due to horizontal inhomogeneities of moisture content at low levels in the incident flow.

Page 11, line 14: quite typical when convective scale are treated explicitly!

Page 11, line 35: wouldn't it be simpler saying "relatively low relative humidity".

Page 12, line 32: drop "were".

Page 13, regarding the effects of forests: I agree that forests may not mitigate flooding, however I wonder (but I am not an expert!) if they may act to reduce landslides (a very important cause of casualties and damages - see page 6, line 25) and reduce the amount of mud in flooded water that may worsen the effects.

Page 14, line 8: I think that the moisture flux is not a "precursor" of precipitation like the other factors, since it is almost contemporary to precipitation.

Page 14, line 12: "very well": again too optimistic and not consistent with the results presented here.

Figures

Fig. 4: the simulated precipitation seems rather low compared to the observed one. Note also that the Simplon station used to sample the simulation is not included in the station list for the observations – why?

Fig. 6 and 7 are not very clear. This is due mainly to the discontinuous (boxes) coloured fields (shade). This should be avoided using an interpolating graphical package.

Fig. 7: panel d) suggests the presence of an "atmospheric river".

Fig. 9a and 9b: it is very difficult to appreciate the differences/similarities with the observations of fig. 5. Perhaps the above figures should be enlarged, plotting on them the observations of fig. 5 with circles.

References

Page 18, line 23: Lago Maggiore (capital).

Suggested additional references:

Bertò, A., A. Buzzi and D. Zardi, 2004: Back-tracking water vapour contributing to precipitation events over Trentino: a case study. *Meteorol. Z.*, 13, 189-200.

Malguzzi, P., G. Grossi, A. Buzzi, R. Ranzi, and R. Buizza, 2006, The 1966 'century' flood in Italy: A meteorological and hydrological revisitation. *J. Geophys. Res.*, 111, D24106, doi:10.1029/2006JD007111.

Bougeault, P., P. Binder, A. Buzzi, R. Dirks, J. Kuettner, R. Houze, R.B. Smith, R. Steinacker, H. Volkert, 2001: The MAP Special Observing Period. *Bull. Am. Meteor. Soc.*, 82, 433-462.

Rotunno, R., and R. Ferretti, 2001: Mechanisms of Intense Alpine Rainfall. *J. Atmos. Sci.*, 58, 1732-1749.