Brief report on IMILAST (endorsed project) for pan-CLIVAR Meeting 2014
(Project homepage: www.proclim.ch/imilast/index.html)

30 May 2014

Introduction
The project “Intercomparison of Mid Latitude Storm Diagnostics (IMILAST)” has started in 2009 and aims at a comprehensive assessment of cyclone tracking methodologies and diagnostics. This activity is focused on the development of quantitative assessment of uncertainties inherent in using different tracking procedures and the provision of uncertainty estimates for cyclone activity in reanalyses and climate model simulations. This will allow to estimate to what extent the observed and projected changes in cyclone activity and extreme events associated with mid latitude cyclones can be quantified.
The project started in 2010 and engages 17 groups and about 40 scientists from around the world operating different cyclone tracking algorithms. The IMILAST consortium developed a comprehensive Science and Implementation Plan where the major science questions and most relevant approaches for their solution are outlined.

Major achievements since 2009 (start of the project)
- By the end of 2010 IMILAST developed the Technical Protocol for an intercomparison experiment of cyclone tracking algorithms, and common data formats, and the input data set (ERA-interim, 1.5° resolution, at that time 1989-onwards). This protocol introduced for the first time some standards in extratropical cyclone tracking algorithms, e.g. by defining a common lifetime threshold of 24h and discussing other standards (e.g. how to treat cyclones over elevated terrain).
- The first intercomparison experiment (2010-2012) provided a set of numerical extratropical cyclone tracks for the 1989-2009 period, calculated with 15 different identification and tracking algorithms using standard input data and output format.
- The project developed a concerted analysis of these data sets (discussed in project meetings in Vienna 2010 and Interlaken 2011), providing a set of diagnostics and a first overview on differences between tracking algorithms.
- First pilot results of IMILAST activity were presented to the scientific community at special sessions on cyclone activity at EGU Assemblies in 2010 and 2011, at the WCRP-UNESCO Workshop on Metrics and Methodologies of Estimation of Extreme Climate Events (Paris, 2010) and the WCRP Open Science Conference (Denver, 2011).
- A number of basic conclusions has been taken from the first experiment (Neu et al. 2013):
    - Consistency across the methods is generally higher for deep (or strong) cyclones than for shallow ones. This conclusion seems to hold also for cyclone frequency and life cycle, as well as for characteristics of interannual variability and trends (Figure 1).
    - The two cyclone case studies provided evidence that consistency across methods was best for the most intense part of the life cycles, while for the periods of development and decay results were more diverse.
    - There is a hint that some schemes might have problems with rapid moving systems. This will be investigated in future work.
    - Differences in absolute total numbers of cyclones are particularly large and imply caution when comparing corresponding results from studies using single but different methods (Figure 1).
    - Differences in the frequency distributions are generally larger in the Northern Hemisphere than in the Southern Hemisphere and are larger over parts of continents (e.g. Europe, North America, the Mediterranean), which are regions of high interest, because storm impacts are high there.
    - An important result specifically relevant to the analysis of climate change impacts is the qualitative consistency shown for geographical linear trend patterns, where regions with strong trends show a good agreement, at least in sign, over most methods (Figure 2).
    - It has proved difficult to clearly associate differences in the identified cyclone characteristics with features of the different schemes, i.e. there is little evidence of clustering of cyclone statistics according to algorithm features (e.g. vorticity schemes vs. mean sea level pressure schemes)
    - In general, the study gives first information on which aspects of cyclone identification and tracking are likely to be independent of the method used (and thus deserve higher confidence) and which aspects should be treated with caution.

- In summer 2012 (in the follow-up of a project meeting in Grindelwald CH), in a concerted action, which was only possible because of the well organized IMILAST community, cyclone tracks have been calculated for one transient ECHAM5 General Circulation Model run with most of the methods. This enabled an assessment of the method related uncertainty in terms of climate change signals of extra-tropical cyclones. The considered scenarios were 20C for the recent climate and A1B for the future climate. The most important conclusion of this second experiment were (see Ulbrich et al. 2013):
    - There is considerable agreement between the results using different algorithms, both with respect to the distribution of cyclones and with respect to climate change signals, although there are important differences in the absolute track numbers.
    - The patterns of model simulated present day climatologies are found to be close to those computed from re-analysis, independent of the method applied.
    - The dominant regional signals of anthropogenic greenhouse gas forcing agree between all of the state-of-the-art methods examined (see Figure 3).
    - Differences between the methods considered are largely due to the different role of weaker systems in the specific methods.
    - Zonal averaging emphasizes more differences in climate signals between tracking algorithms than the consideration of patterns.
    - The different methodologies agree in terms of an increasing number of intense cyclones over the Aleutian region and the eastern North Atlantic. These results are in line with multi model studies using individual methods.
- A set of 22 extreme storms over the North Atlantic has been defined to study the representation of extreme storms with different methods. This set can be used for other studies related to extratropical cyclones

- A third experiment has provided extended track data for the ERA-Interim period of 1979-2009. Analysis work is ongoing and will be published in TELLUS-A as a special issue.

An important general achievement of the project is the strong enhancement of knowledge exchange and cooperation within the scientific community working in the field of extratropical storm analysis. This cooperation allows improving significantly the knowledge on numerical identification and tracking schemes and on related methodological uncertainties. This also improves the understandability and supports the interpretation of results for any users.

How can CLIVAR be most useful and relevant to IMILAST activities moving forward?

IMILAST is relevant for many activities and two of the main challenges of CLIVAR:
- to provide useful prediction of climate variability and change through the use of improved climate models, and
- to monitor and detect changes in our climate system.

Therefore, the exchange of information and discussions of IMILAST with the corresponding CLIVAR communities will be beneficial for both sides.

IMILAST tries to get funding for coordinating activities from different parties (currently from insurance industry; proposal for COST action is submitted). Corresponding support from CLIVAR would be extremely helpful to pursue the objectives.

Next steps:

- Advance and extend the analysis of third experiment (ongoing Tellus-A special issue papers)
- Comparison of representation of extreme storms between automated methods and to manual analysis
- Concerted analyses of climate change signal (based on CMIP5 results)
- Intensification of dialogue with stakeholders and users, focus on more applied issues related to the impact of extra-tropical cyclones (windstorm losses, floods, storm surges)
- Others…

Time frame and intensity of activities depend on available funding.

Key figures

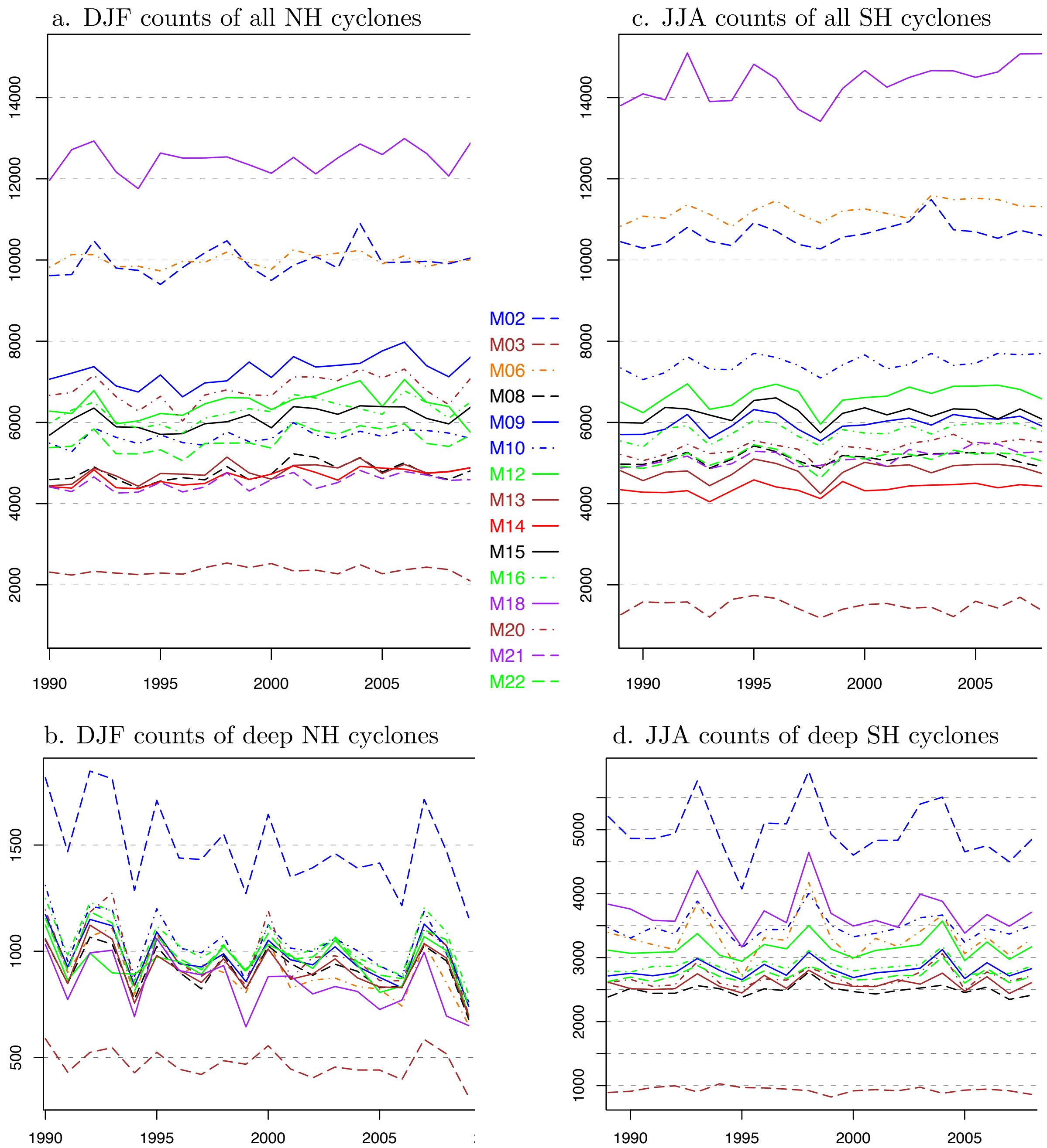

***Figure 1**: Time series of NH (a-b) and SH (c-d) cyclone center counts in NH (DJF) and SH (JJA) winter, respectively, calculated by 15 different identification and tracking algorithms (M= Method). „Deep" cyclones here are those with core pressure ≤ 980 hPa (only for methods that output cyclone core pressure; for „deep cyclones" only time steps where the pressure is ≤ 980 hPa are counted). Note that for M06 cyclone counts have been doubled to account for its unique 12h time-step. Source: Neu et al. 2013 (Figure 6).*

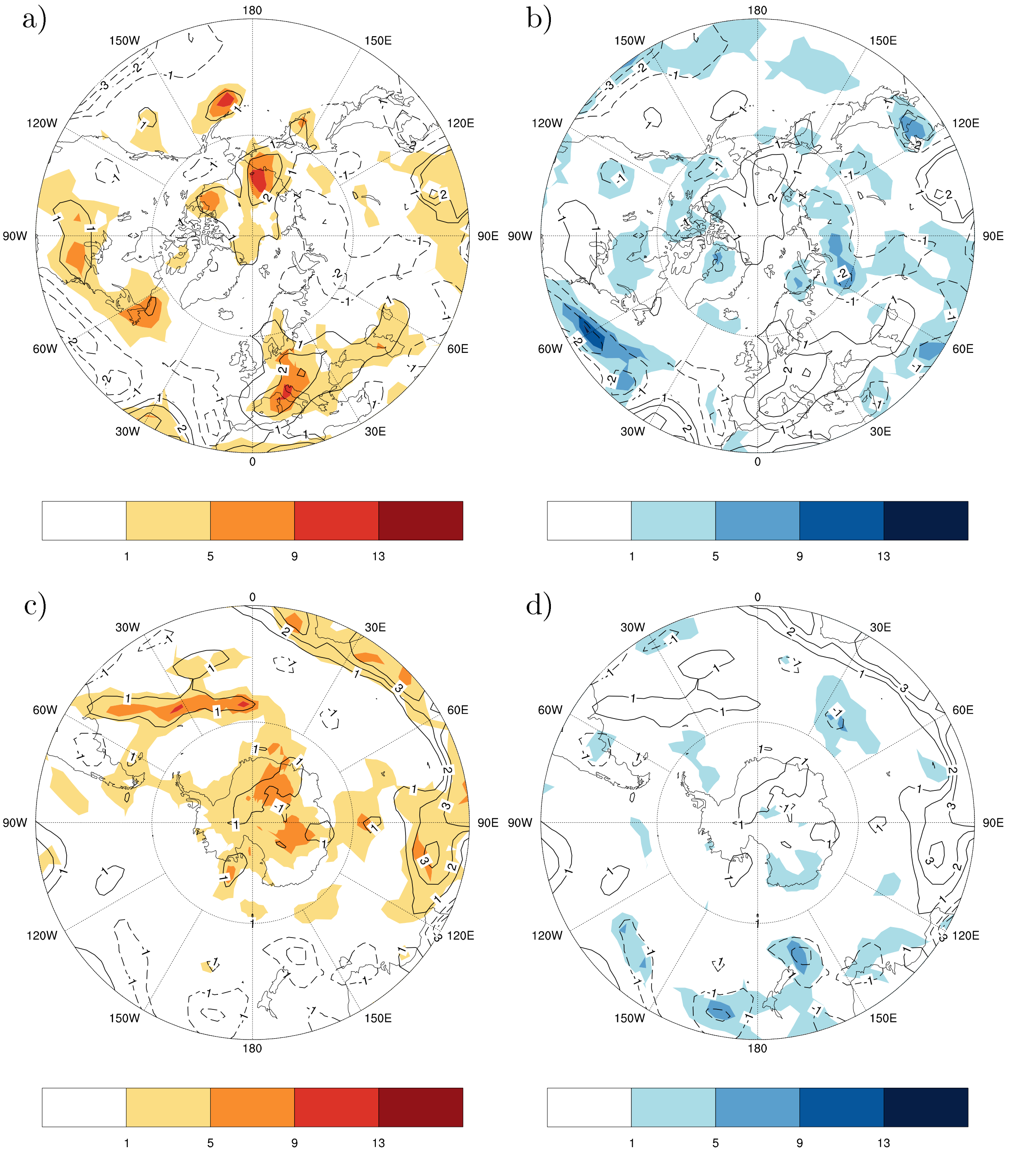

Figure 2: *Geographical patterns of 20-year winter trends of cyclone track density, calculated by 15 different cyclone identification and tracking schemes. The color scale represents the number of methods with a significant positive 932 (a) and negative (b) relative trend (significance level of p>90%) in the Northern Hemisphere (DJF), the 934 contour lines represent the magnitude of the method ensemble-mean relative trend (in % change, per year, of the average yearly track density). c) and d): same as a) and b) 936 respectively, but for SH (JJA). Source: Neu et al. 2013 (Figure 8).*

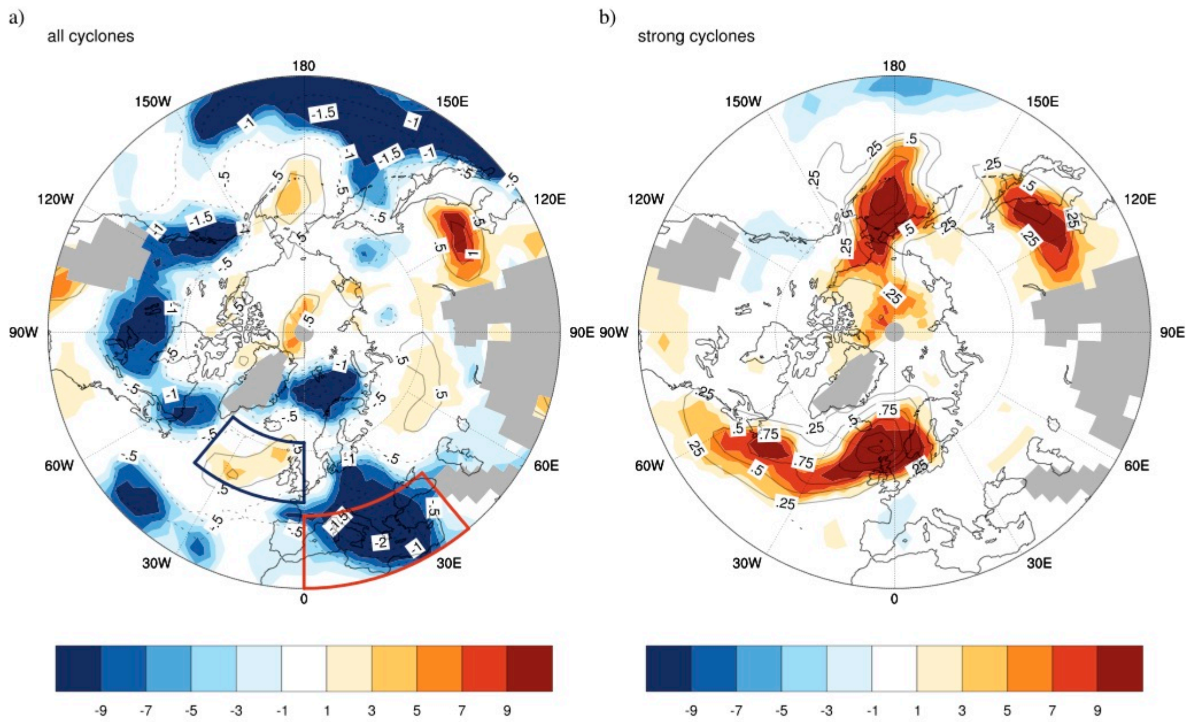

***Figure 3**: Comparison of the climate change signal (2061-2100 vs. 1961-2000 in ECHAM5/OM1 model) from 11 different identification and tracking algorithms. Number of methods showing a significant (0.95) climate signal of track density (shading) and absolute values of the method mean signal [tracks/winter lat**−2**] (isolines) for a) all and b) strong cyclones. Blue/red shadings indicate number of methods with significant negative/positive changes. Contour level of isolines is a) 0.5 [tracks/winter lat**−2**] and b) 0.25 [tracks/winter lat**−2**], whereas solid/dashed lines indicate positive/negative changes. Areas with orography higher than 1500m are masked out with grey shading. Source: Ulbrich et al. 2013 (Figure 3).*

Project publications

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