Structures of moisture transport to Norway associated with a winter cyclone in the North Atlantic

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Introduction

Understanding of the atmospheric processes leading to periods of extreme precipitation is still limited. Previous studies have shown that both, remote and local moisture transport contribute to heavy precipitation events in Norway via moisture conveyor belts or 'atmospheric rivers', which are linked to mid-latitude cyclones.

The aim of this work is to increase insight into the processes and the spatial structures and scales of moisture transport to high latitudes associated with mid-latitude cyclones.

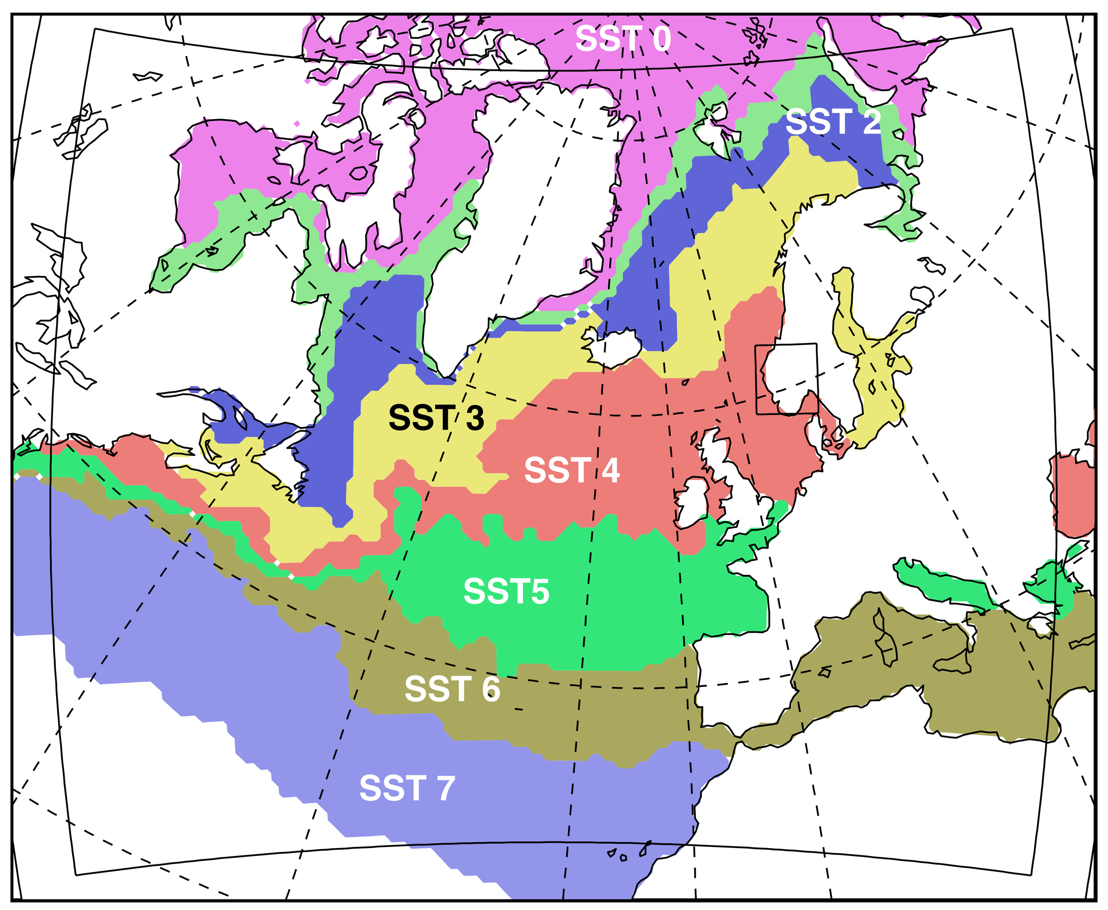

Figure 1: Setup of the Atlantic tracer initialisations based on sea-surface temperatures (see Table).

Method

We studied a period of above-average precipitation in southern Norway during winter 2006/07 (1-31 Dec 2006), which was related to a series of mid-latitude cyclones moving into Scandinavia.

A number of high-resolution simulations was conducted with a limited-area NWP model, using ECMWF's high-resolution operational data for the initial and boundary conditions. The limited-area model is fitted with water vapour tracers, which allow to tag water vapor at its area of evaporation, and to follow it's movement through the model's hydrological cycle (Sodemann, 2006; Sodemann et al., in prep.).

Figure 1 shows the areas of tracer evaporation in the North Atlantic which were chosen based on sea surface temperature ranges (Table 1). Gray tracer is used for water vapor advected into the domain along the south-western boundaries. Tracer release was started after a 3h initialisation period.

(a) Vertically integrated water vapor (b) Tracer fractions and SLP

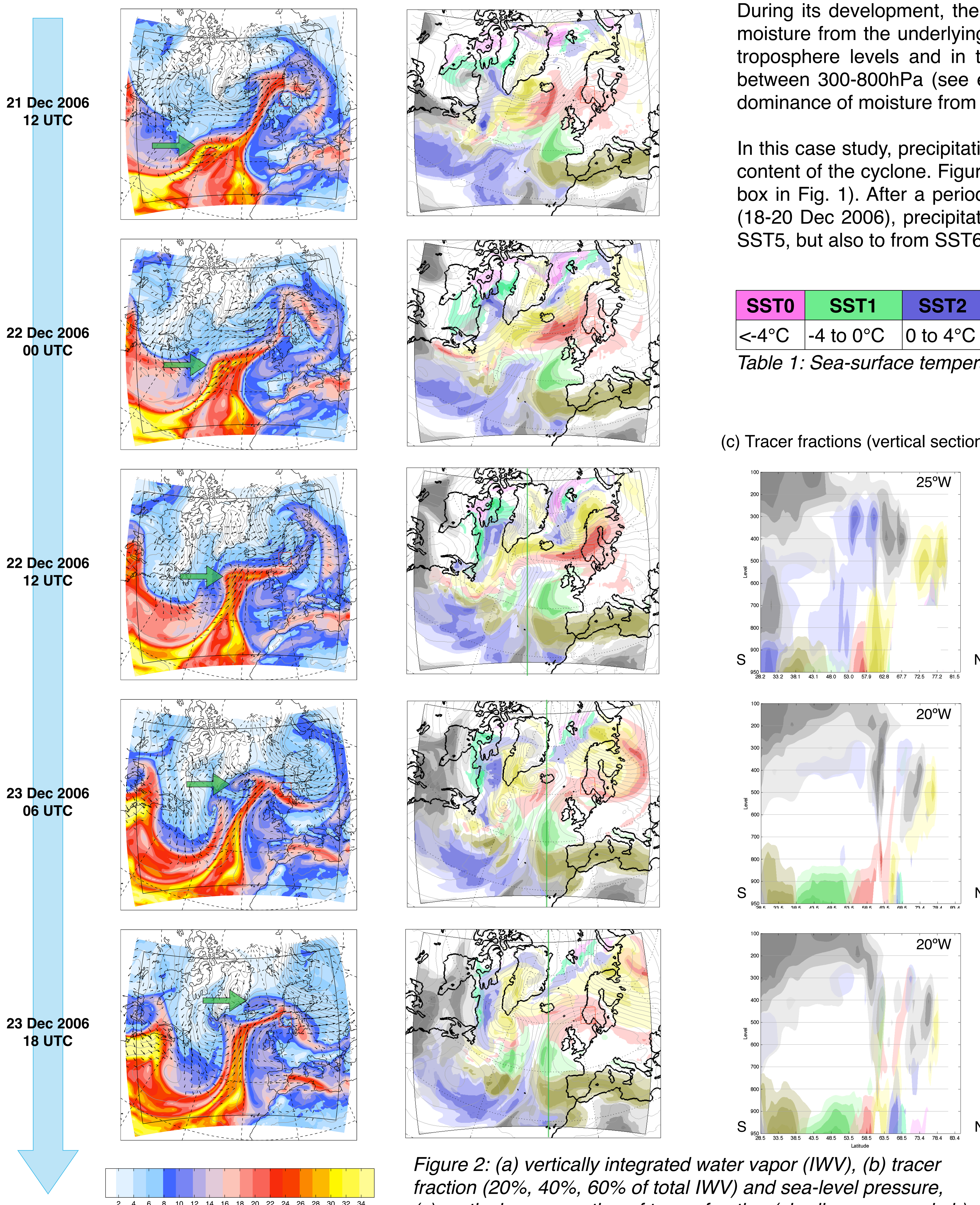

Figure 2: (a) vertically integrated water vapor (IWV), (b) tracer fraction (20%, 40%, 60% of total IWV) and sea-level pressure, (c) vertical cross-section of tracer fraction (shading same as in b). Sections are taken along the respective green line in (b).

Results

During its development, the cyclone examined here (Fig. 2a, green arrows) quickly acquires moisture from the underlying ocean surface. Moisture resides longer in the cyclone at middle troposphere levels and in the warm sector. Hence, most long-range transport takes place between 300-800hPa (see e.g. tracer from region SST 7 in Fig. 2c). Noteworthy is also the dominance of moisture from outside the domain at higher levels.

In this case study, precipitation in southern Norway is rather indirectly affected by the moisture content of the cyclone. Figure 3 shows a time series of precipitation in southern Norway (black box in Fig. 1). After a period dominated by precipitation from the initial atmospheric moisture (18-20 Dec 2006), precipitation originates from the immediate surrounding regions SST4 and SST5, but also to from SST6 and SST7, as well as the south-western boundaries.

SST0	SST1	SST2	SST3	SST4	SST5	SST6	SST7	SW
<-4°C	-4 to 0°C	0 to 4°C	4 to 8°C	8 to 12°C	12 to 16°C	16 to 20°C	20 to 24°C	N/A

Table 1: Sea-surface temperatures for the evaporative tracer source regions

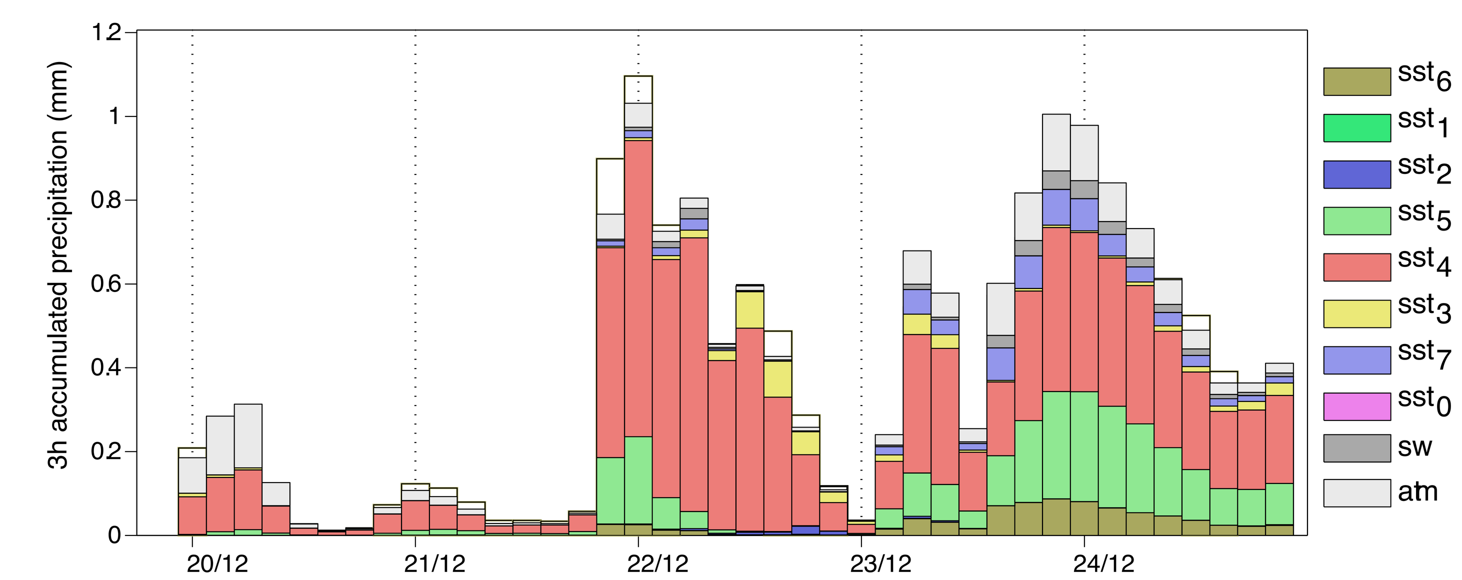

Figure 3: Time series of precipitation in southern Norway (black box, Fig. 1). Due to numerical effects the total is slightly different from the sum of the tracers (white area).

Conclusions

The spatial structure of moisture from different sources, and its temporal evolution are presented in an innovative visualisation. Remarkable are the high turnover of moisture in the cyclone. Long-range transport of moisture is rather associated with than ocurring within the cyclone. Our results provide new insight into the mechanisms of moisture transport to high latitudes with mid-latitude cyclones. The simulation setup will further be used for understanding the role of SST anomalies in heavy precipitation periods, and the climatological origin of precipitation in Noway.

References

Sodemann, H., Wernli, H. and Schwierz, C.: Sources of water vapour contributing to the Elbe flood in Central Europe, August 2002, in prep.

Sodemann, H., 2006: Tropospheric moisture transport: Lagrangian and Eulerian perspectives. Diss No. 16623, ETH Zurich.

Acknowledgements

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