

**Scientific report for the MPIPKS Workshop:  
Exploring Complex Dynamics in High-Dimensional Chaotic Systems:  
From weather forecasting to oceanic flows**

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The main focus of the Workshop was to study forecasting tools for high dimensional chaotic systems. There are a number of well-known approaches to tackle this problem in low dimensional systems, but making useful forecasts becomes tremendously difficult as the number of degrees of freedom increases. The Workshop analyzed two complementary approaches to predicting highly complex systems. On the one hand, the dynamical-system approach, that is based on concepts such as unstable and stable manifolds, Lyapunov vectors and exponents, chaotic attractors, etc are exploited to forecast the future. On the other hand, the optimization/control theory approach, which, starting from the knowledge of past time series, is based on the implementation of statistical tools like the ensemble Kalman filter, data assimilation, Bayesian estimations, etc. A common problem in either approach is how to deal with the fact that our observations do not coincide with the predicted trajectory and how to use the information from new observations to improve the performance of the prediction algorithm for the next time window. During the Workshop it has become clear that the unavoidable inaccuracies of the mathematical models (think of the ocean flow and weather model applications) limit the performance of any approach based solely on dynamical-system theory. At the same time, knowledge of the system dynamics (possibly in the presence of noise) is essential for the construction of ensembles of trajectories and thereby to make optimal predictions.

The most appreciated aspect of the Workshop has been the opportunity offered to each participant of fruitfully interacting with members of different communities: nonlinear dynamical systems, statistical mechanics, weather forecasts, and oceanic flows. Moreover, the whole range from fundamental theoretical problems through toy models up to particular applied implementations has been covered. As a result, profitable exchanges of ideas took place during the oral presentations at question time (more than for average Workshops), and during the two poster sessions. Quite remarkable was also the lively discussion during the Round Table, when the different methods adopted by the European and American forecasting centers were mutually compared. Finally, the friendly environment at the MPIPKS Institute contributed to extend the discussions at all aspects, and to trigger new scientific collaborations.