NICE – Network for Ice sheet and Climate Evolution

LSCE-IPSL / CLIMPACT

Combination of multi-model ensembles by a Bayesian approach

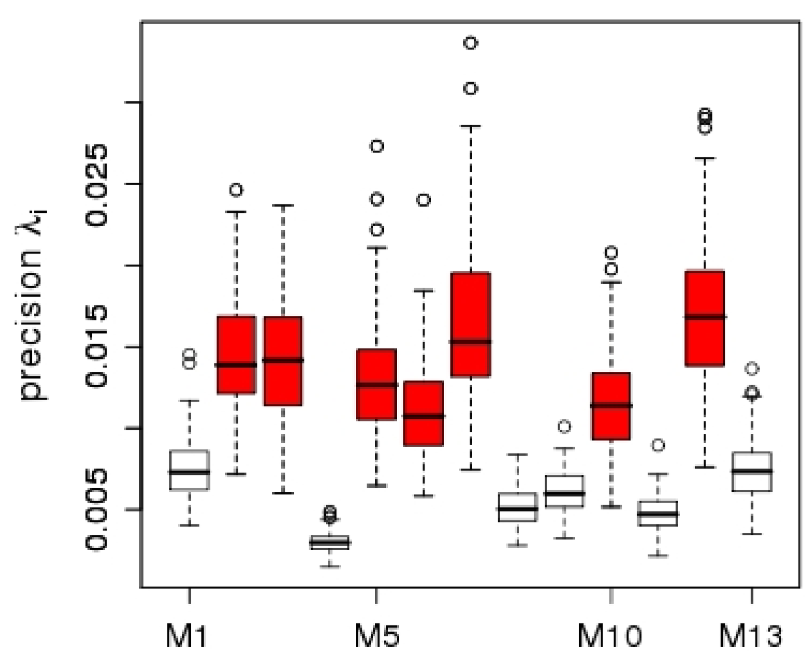
Assessment of future ice accumulation over the oceanic Arctic region

Projections are an important means for policy advice in the context of climate change. The performance of general circulation models (GCM) may vary across regions or periods, it is thus not evident to choose a specific GCM to project. Here a method to merge multi-model GCM projections to a Bayesian model average (BMA) is presented. The influence of each GCM is weighted with regard to verifying observations. The BMA predictions serve for the assessment of the evolution of ice accumulation over the oceanic Arctic region. SRES scenarios A2 and B1 are used to project to the periods 2046-2065 and 2081-2100. A continuing decrease of ice accumulation shows for the A2 scenario, whereas it stabilises for the B1 scenario in the second prediction period.

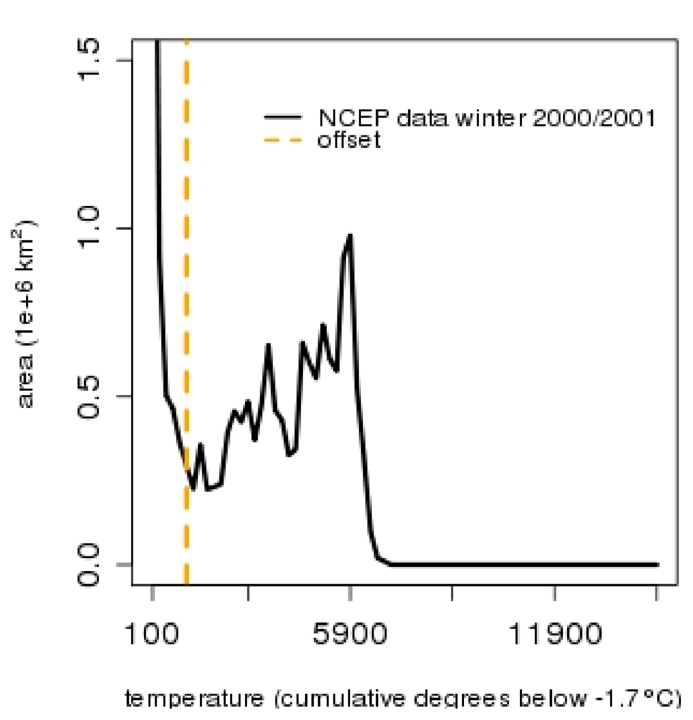
Motivation

- Merge multi-model GCM output to a Bayesian model average.
- Obtain predictive distribution by means of Bayesian approach so that credibility intervals are available.
- Allow for time dependence of target variable.
- Assess evolution of ice accumulation over oceanic Arctic region.

Model 1: BCCR-BCM2.0
Model 2: CGCM3.1(T47)
Model 3: CNRM-CM3
Model 4: CSIRO-MK3.0
Model 5: CSIRO-MK3.5
Model 6: ECHAM5\MPI-OM
Model 7: ECHO-G
Model 8: GFDL-CM2.0
Model 9: GISS-ER
Model 10: IPSL-CM4
Model 11: MIROC3.2(medres)
Model 12: MRI-CGCM2.3.2
Model 13: PCM



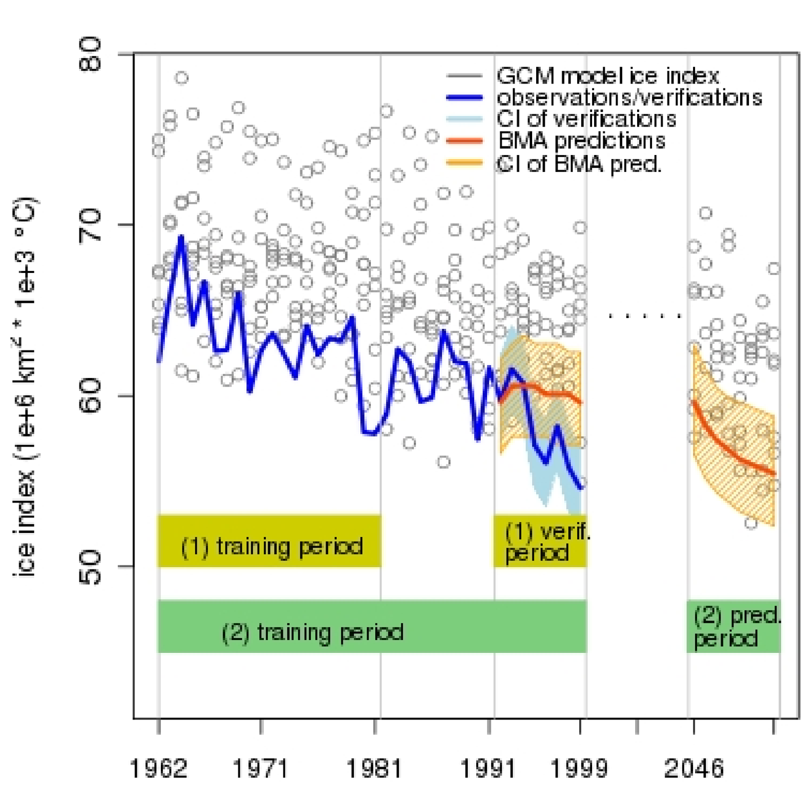
Ice index creation



- Daily Surface temperature (SAT) to describe ice accumulation over oceanic Arctic region (GCM models, NCEP reanalysis data),
- Classify gridpoints by their iciness: sum up number of degrees below -1.7 °C per freezing season (September to May),
- Winter ice area : accumulated area of classified gridpoints,
- Winter ice index: integral over accumulated area (black line), weighted by classes.

Ice index development: DAMOCLES project (`http://www.damocles-eu.org/`).
Data source: PCMDI (`http://www-pcmdi.llnl.gov/`).

Bayesian model averaging



Θ parameter vector

D data vector

P prediction

$$[\Theta|D] \propto [\Theta][D|\Theta]$$

$$[P|D] = \int [P|\Theta][\Theta|D]\, d\Theta$$

Data assimilation - state space model

data equations

$$X_{it} = c_T + \mu_t + d_t + b_i + \epsilon_{it} \quad i=0,\dots,M \qquad t \text{ in training period}$$

$$Y_{it} = c_P + \nu_t + \delta_t + b_i + e_{it} \quad i=1,\dots,M \qquad t \text{ in prediction period}$$

$i=0,\dots,M$ observations $X_{it}=c_T+\mu_t+d_t+b_i+\epsilon_{it}$ $Y_{it} = c_P + \nu_t + \delta_t + b_i + e_{it}$ model output

state space equations

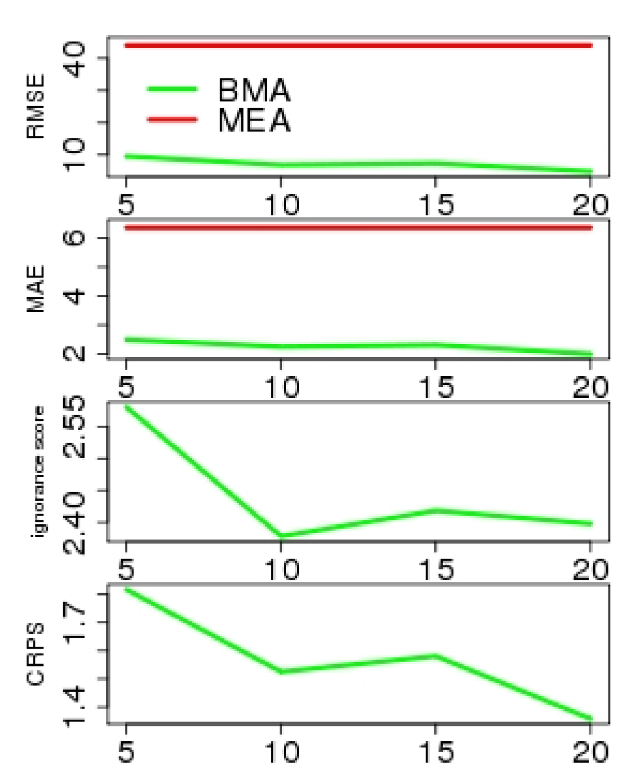
$$\mu_t = \phi\, \mu_{t-1} + \omega_{\mu t} \qquad t \text{ in training period}$$

$$d_t = d_{t-1} + k_1 + \omega_{dt}$$

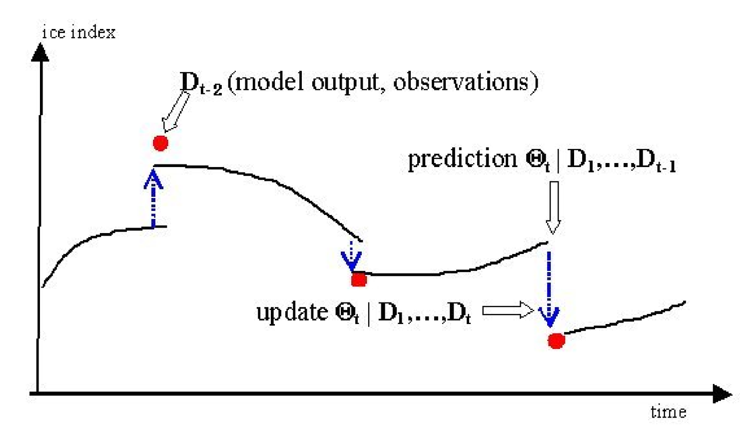
$$\nu_t = \phi\, \nu_{t-1} + \omega_{\nu t} \qquad t \text{ in prediction period}$$

$$\delta_t = \delta_{t-1} + k_2 + \omega_{\delta t}$$

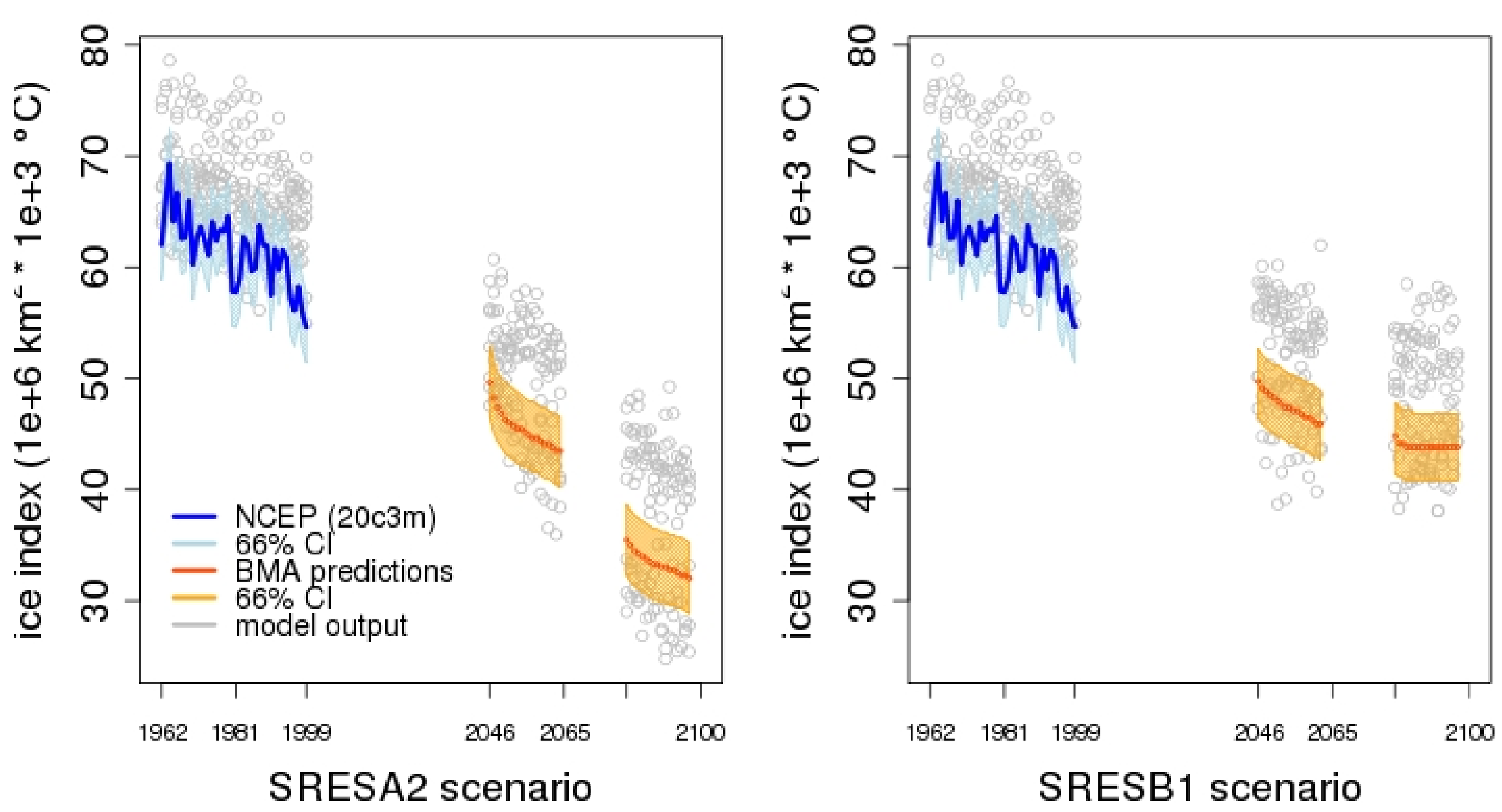
Verification



All data and state variables are assumed to be Gaussian. A Kalman filter is integrated into a Gibbs Markov Chain Monte Carlo procedure (MCMC) to obtain the posterior distribution of the parameters.



Results



Harvey, A. C., T. M. Trimbur, and H. K. V. Dijk (2007): Trends and cycles in economic time series: A Bayesian approach. *Journal of Econometrics*, **140**, 618–649, doi:10.1016/j.jeconom.2006.07.006.

Kallache, M., E. Maksimovich, P. A. Michelangeli and P. Naveau (submitted): Combination of multi-model ensembles by a Bayesian approach: Assessment of ice accumulation over the oceanic Arctic region.

Tebaldi, C., R. L. Smith, D. Nychka, and L. O. Mearns (2005): Quantifying uncertainty in projections of regional climate change: A Bayesian approach to the analysis of multi-model ensembles. *Journal of Climate*, **18** (10), 1524–1540.

Malaak Kallache

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