Impact of the autumn snow cover on high latitude climate variability

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Eurasian snow cover impact on climate

- Snow-covered land : key role in climate system due to snow unique radiative and insulating properties
- Snowpack may impact not only local meteorological conditions but also global circulation patterns:

Eurasian autumn snow cover influences wave trains propagating downstream over the North Pacific and vertically into the stratosphere *(Cohen et al., 2007; Saito et al., 2001; Orsolini and Kvamstø, 2011)*

- We address the impact of the snowpack (snow cover and depth) on forecasts during autumn/early winter with a focus on high northern latitudes

→Does snow initialisation have a quantitative impact on monthly to seasonal prediction skill ?

- In autumn/early winter at high latitudes → influence of snow is conveyed by soil insulation and long-wave cooling, not short-wave albedo. (e.g. Dutra et al., 2011)

Seasonal ensemble prediction system from ECMWF

- High-resolution (T255;l62) coupled ocean-atmosphere model (IFS HOPE V4)
- land surface module is HTESSEL with improved hydrology, and improved 1-layer snow scheme as in Dutra (2011)

Experiment design:

- We transposed the GLACE-2 methodology (Koster et al., 2010), which focused on soil moisture impact during warm season, to "snow"
- We carry two sets of historical re-forecasts covering recent years (since 2004), one with accurate snow initialisaton and one with scrambled snow initialisation; forecasts are identical in every other aspect.
- We "scramble" snow variables in a consistent way: snow T, density, albedo, SWE

A first ensemble of **forecasts with accurate snow initialisation**

Series 1

Initialize snow with reanalyses → Perform ensembles of retrospective seasonal forecasts → Evaluate forecasts against obs

Initialize atm/ocean/land with reanalyses → Perform ensembles of retrospective seasonal forecasts

- 12-member ensemble
- atmospheric / oceanic / land initialisation
- forecast length : 2-month
- 4 Start dates: OCT 15, NOV 1, NOV 15, DEC 1
- 6 Years 2004-2010
- realistic snow initialisation from re-analyses ERAINT

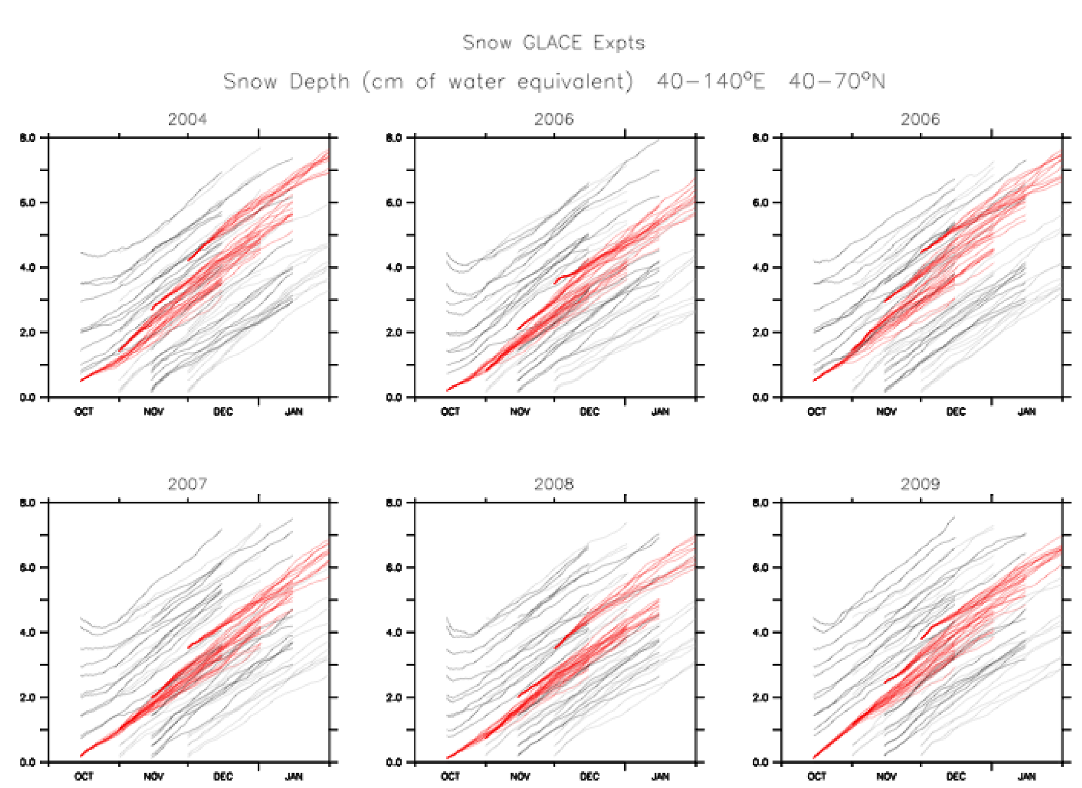
A second set of **forecasts with "scrambled" snow initialisation**

Series 2

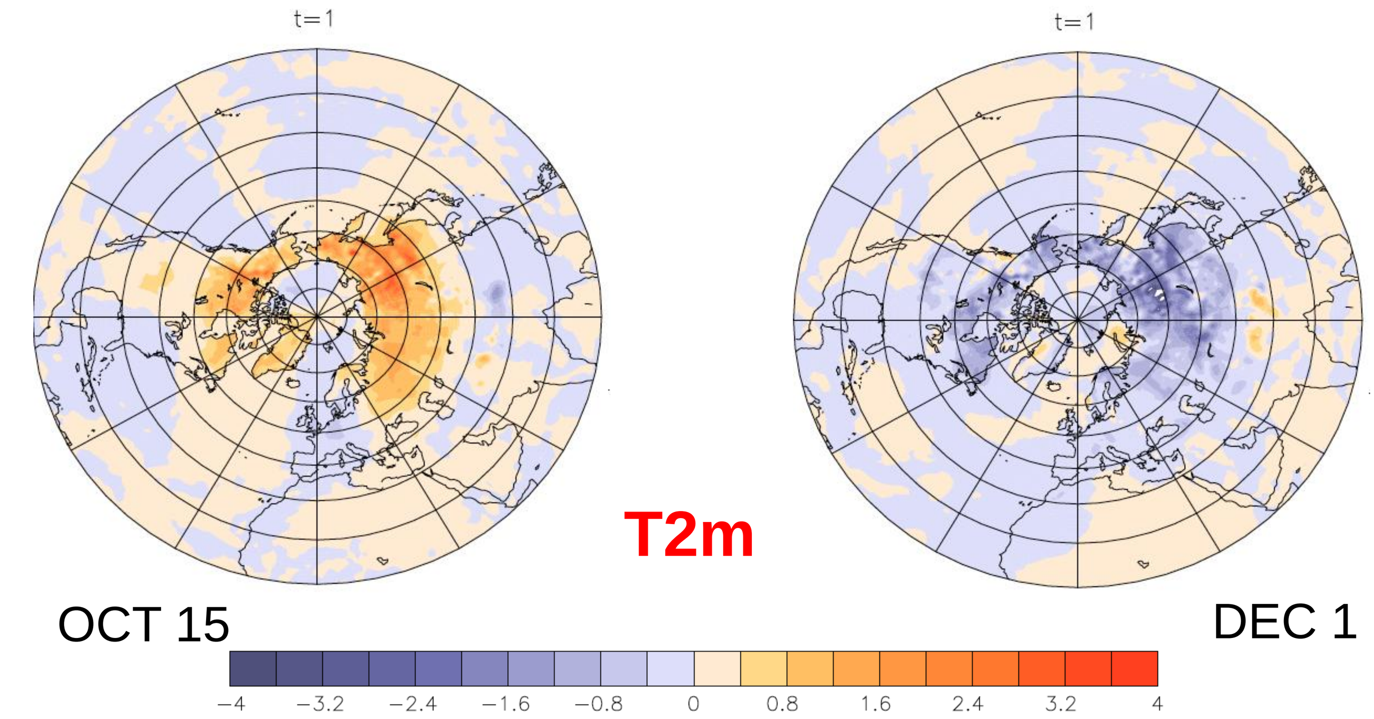
"Scrambled" snow initialization! ...es → Perform ensembles of retrospective seasonal forecasts → Evaluate forecasts against obs

Initialize atm/ocean/land with reanalyses → Perform ensembles of retrospective seasonal forecasts

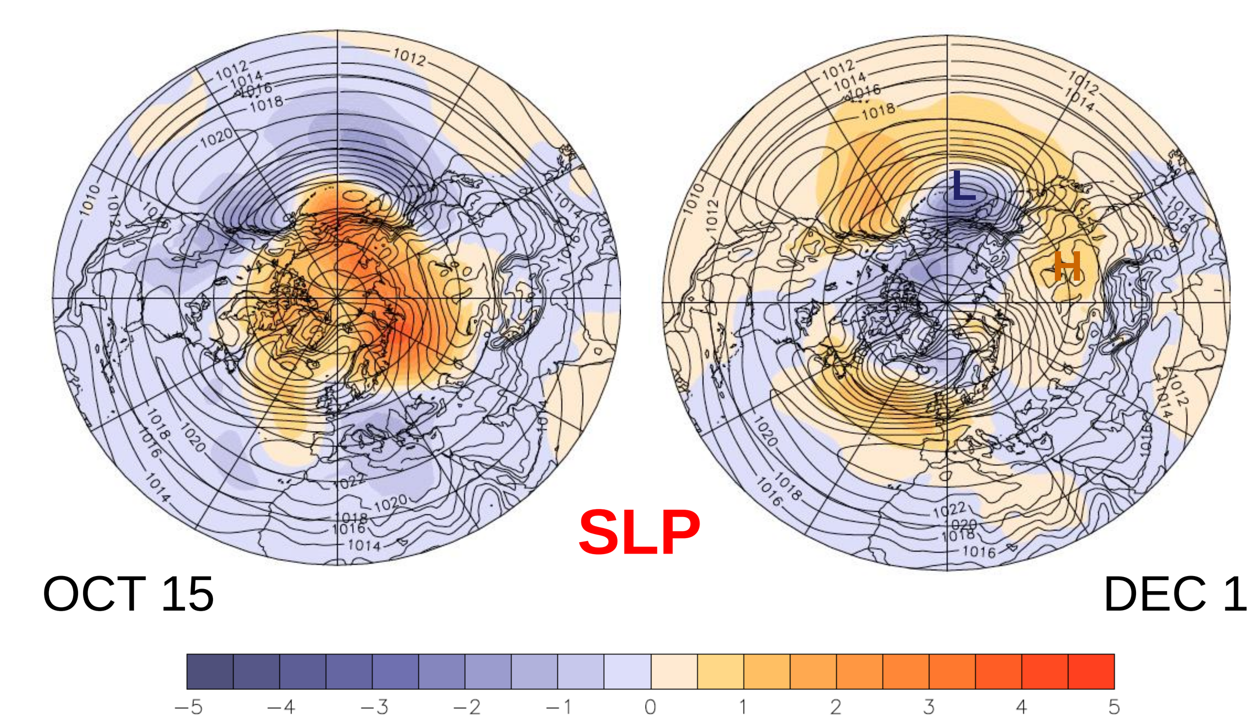
- identical , <u>but</u> "scrambled snow" using other dates or years from the same set



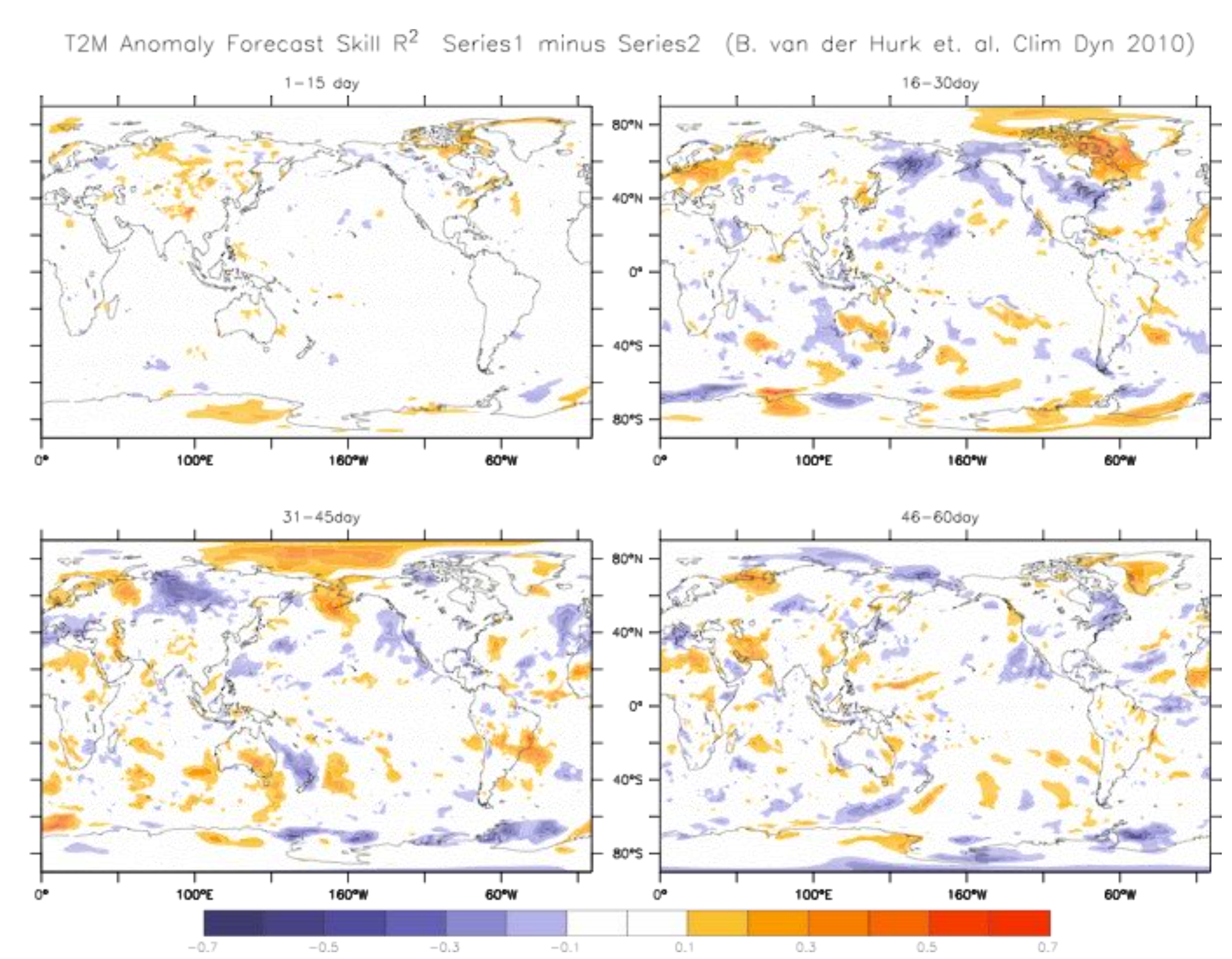
Forecasted snow depth over Eurasia: Time-evolution of snow depth (cm of water equivalent) averaged over Eurasia for the ensemble forecasts comprising 6 years. 4 start dates, and 11 members. Red curves indicate Series1, and grey or black curves Series2.



Surface temperature differences: ensemble-mean difference in T_{2m} (Series1-Series2). For the first 15-day sub-period for the start dates of OCT 15 (left) and DEC 1 (right). Presence of snow pack → colder lower atmosphere (4K)



Surface pressure differences at one-month lead: Ensemble-mean difference in SLP (Series1-Series2) through the second forecast month (color shading) for OCT 15 (left) and DEC 1 (right). Contours denote the ensemble mean SLP for Series 1 (hPa). Indicative of circulation changes : high snow → deeper Aleutian Low, stonger Siberian High, lower SLP over Arctic



- Forecast skill increment for T_{2m} .Forecast skill increment (Series1-Series2) r^2 defined as the square of the anomaly correlation coefficient (ACC) between observation and ensemble-mean forecast. Each r^2 is multiplied by the sign of the ACC. Model anomalies are deviations from model climatologies valid for each start date and lead time. Observational anomalies are taken from ERAINT climatology over the years 2004-2009.
- Initial (0 lead) weak positive increment over snow-covered land
- Very large (~0.7) increment over Arctic at 30-day lead

Note: GLACE2 →soil moisture skill increment ~0.3

- Teleconnection influence 30-day lag consistent with remote forcing through planetary wave propagation (Saito et al., 2001; Cohen et al., 2007)

Note: a downward stratospheric influence probably cannot be seen in our 2-month forecasts

Preliminary Conclusions

- Snow pack initialisation has great potential to improve forecast skill in surface temperature over the Arctic, at monthly lead times. The patchiness of skill increment remains to be explained
- Heavy snow pack has cooling effect on lower atmosphere, decoupling the lower atmosphere from the soil layer below. Snow albedo feedback has limited role due to low insolation in autumn
- Our high-resolution coupled forecasts partly confirm results from earlier studies about:

✓ Eurasian autumn snowpack and Aleutian Low/Siberian High co-variability
✓ Eurasian autumn snowpack influencing Arctic heights

References

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