Is snow cover an underrated source of springtime sub-seasonal predictability ?

Rationale and first results

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[1]CNRM (Meteo-France & CNRS)

[2]BSC

30 May 2023 BSC Lunch seminar

Who am I (and why am I visiting BSC) ?

- Agronomy Msc degree in 2001 (AgroParisTech)

- Working at Météo France in Toulouse since 2007

- Position at CNRM in 2013 as research engineer

- **2014-2015 : the stars align** to start with effective climate research activity

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- **2014-2015 : the stars align** for increasing my research activity

  — Oct. 2014 : 3rd General Assembly of the FP7-SPECS [1] project (2012-2016) in Toulouse

  — Coordinator : Paco Doblas-Reyes

  — Application to a Severo Ochoa mobility grant and setup of a **3-month scientific visit at BSC in 2015**

- Submission of my first 'First-authored' paper in ClimDyn

- Pre-requisite for my employer to let me engage in a PhD thesis (2016-2019)

[1]Seasonal-to-decadal climate Prediction for the improvement of European Climate Services

- **Thesis** : *Impact of soil moisture on summer climate predictability over mid-latitudes*

- **Main research themes :** *Sources of (sub)-seasonal predictability related to the land surface, land surface initialization strategy in dynamical forecast systems, predictability of extremes*

  Personal page http://www.umr-cnrm.fr/spip.php?article938&lang=en

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- Project ERA4CS-MEDSCOPE[1] (2017-2020) : collaboration with CMCC, and Stefano Materia in particular

  — S2S-S2D WCRP conference in Boulder, CO (Sept. 2018)

[1]MEDiterranean Services Chain based On climate PrEdictions

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- Project ERA4CS-MEDSCOPE[1] (2017-2020) : collaboration with CMCC, and Stefano Materia in particular

  — 1-month visit to CMCC in Bologna in Oct. 2019

  — 2 great 'companion' papers

    ‣ Materia, S., Ardilouze, C., Prodhomme, C. et al. Summer temperature response to extreme soil water conditions in the Mediterranean transitional climate regime. Clim Dyn 58, 1943–1963 (2021)

    ‣ Ardilouze, C., Materia, S., Batté, L. et al. Precipitation response to extreme soil moisture conditions over the Mediterranean. Clim Dyn 58, 1927–1942 (2020)

- Informal discussion in 2022 : a new potential study came up

- Interesting preliminary results → opportunity to come back to BSC

[1]MEDiterranean Services Chain based On climate PrEdictions

Initial spark : a result from Materia et al. 2020

- *Materia, S., Muñoz, Á. G., Álvarez-Castro, M. C., Mason, S. J., Vitart, F., & Gualdi, S. (2020). Multimodel Subseasonal Forecasts of Spring Cold Spells: Potential Value for the Hazelnut Agribusiness, Weather and Forecasting, 35(1), 237-254*

- Multi-system evaluation of the **sub-seasonal prediction skill for 2-m Temperature**

Week 2   Week 5
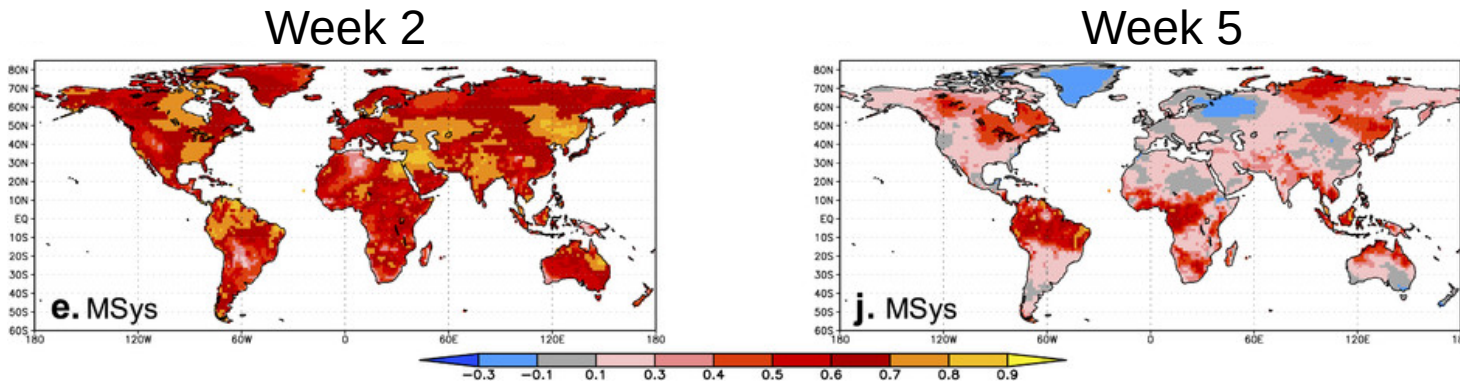
Forecast skill (Spearman correlation) for 2-m temperatures predicted by a multisystem ensemble. Concatenation of three start dates (1 Mar, 15 Mar, and 1 Apr) over 19 years.

- Significant skill over N-E Asia and and parts of North America at week 5

- An unexpected result left in the air

  — Can we reproduce this result with a different subset of forecast systems ?

  — Could it be related to the snow cover ?

  — If so, what are the underlying mechanisms at play ?

Can we reproduce the result ?

- First challenge : build a new multi-system sub-seasonal reforecast (Crucial fields are missing in the systems used by Materia et al)

- The S2S database (Vitart et al. 2017) : 12 forecast systems

Current model details

	Model version	Implement. date in S2S	Time range	Resolution	Ens. Size	Frequency	Re-forecasts	Rfc period	Rfc frequency	Rfc size *7
BoM (ammc)	POAMA P24	01/01/2015	d 0-62	T47 L17	32+1	2/week (Thu, Sun)	fixed	1981-2013 (model version date 01/01/2014)	6/month (always on the 1st, 6th, 11th, 16th, 21st and 26th)	32+1
CMA (babj)	BCC-CPS-S2Sv2	11/11/2019	d 0-60	T266 L56	3+1	2/week (Mon, Thu)	on the fly	past 15 years	2/week (Mon, Thu)	3+1
CNR-ISAC (isac)	GLOBO	08/06/2017	d 0-32	0.75° x 0.56° L54	40+1	weekly (Thu)	fixed	1981-2010 (model version date 08/06/2017)	every 5 days (the same days each Rfc year *1)	4+1
CNRM Model (lfpw)	CNRM-CM 6.1	22/10/2020	d 0-47	T359 L91	25	weekly	fixed	1993-2017 (model version date 01/07/2019)	every 7 days (starting from 31/12/1992 *2)	10
ECCC (cwao)	GEPS 7	02/12/2021	d 0-32	Yin-Yang grid at 0.35° uniform resolution (~39 km) L85	20+1	weekly (Thu)	on the fly	2001-2020	weekly (Thu)	3+1
ECMWF (ecmf)	CY47R3	13/10/2021	d 0-46	Tco639 L137 (about 16 km) up to day 15 and Tco319 (about 32 km) after day 15	50+1	2/week (Mon, Thu)	on the fly	past 20 years	2/week (Mon, Thu)	10+1
HMCR (rums)	RUMS	15/09/2022	d 0-46	0.9° x 0.72° L96	40+1	weekly (Thu)	on the fly	1991-2015	weekly (Thu)	10+1

- Wide range of set-ups (ensemble size, reforecast period, reforecast frequency, time range, provided fields)
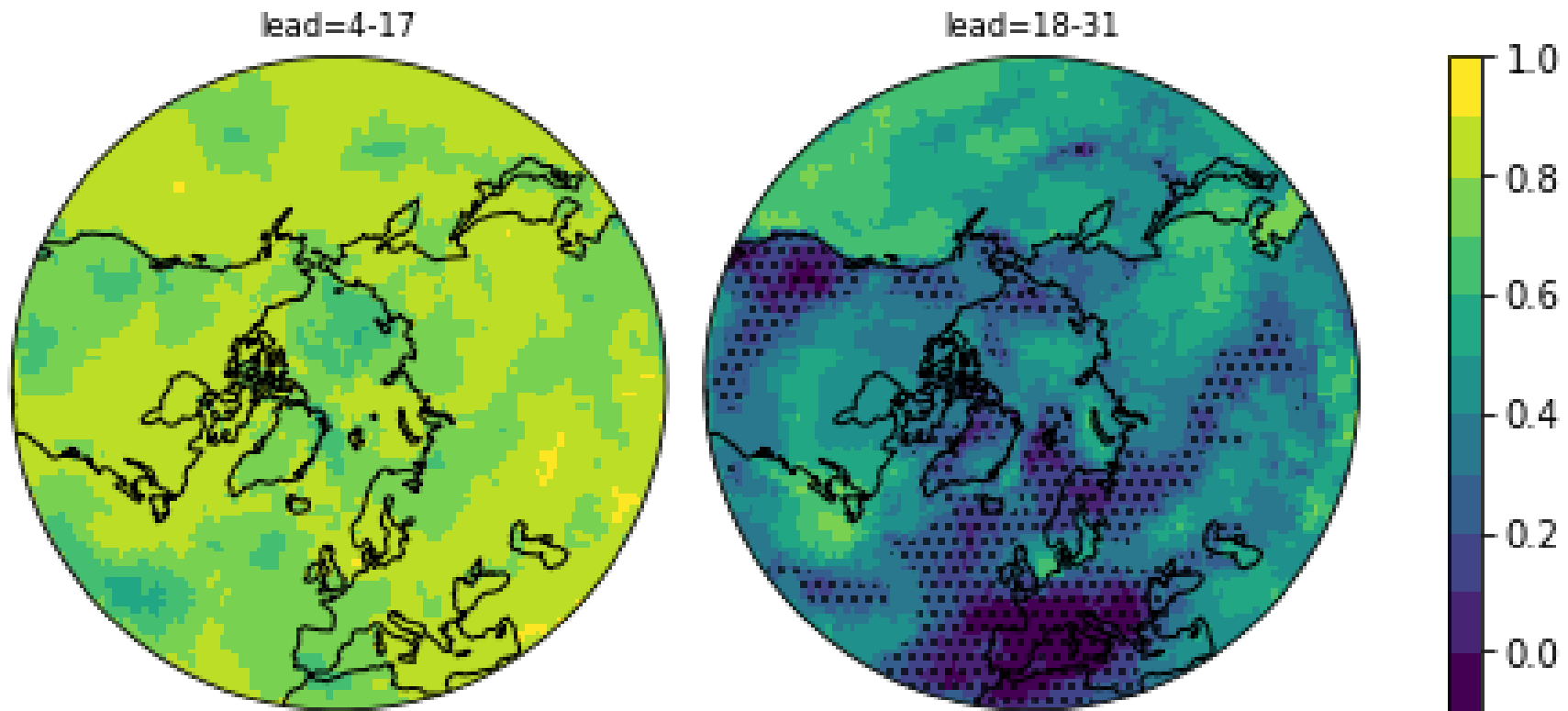
Can we reproduce the result ?

- **40-member multi-system** based on 4 models : ECMWF, CNRM, HMCR and BOM (10 members each)

- **Concatenation of 4 consecutive early spring start dates** over 18 years (1996 – 2013) => 72 start dates

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Multi-model Early spring

lead=4-17 lead=18-31

Forecast skill (Pearson correlation) for 2-week mean 2-m temperatures predicted by a multisystem ensemble. Reference : ERA5
Concatenation of four start dates (~27 Feb, 6 Mar, 13 Mar, and 21 Mar) over 18 years.

Can we reproduce the result ?

- 40-member multi-system based on 4 models : ECMWF, CNRM, HMCR and BOM (10 members each)

- Concatenation of 4 consecutive late spring start dates over 18 years (1996 – 2013) => 72 start dates
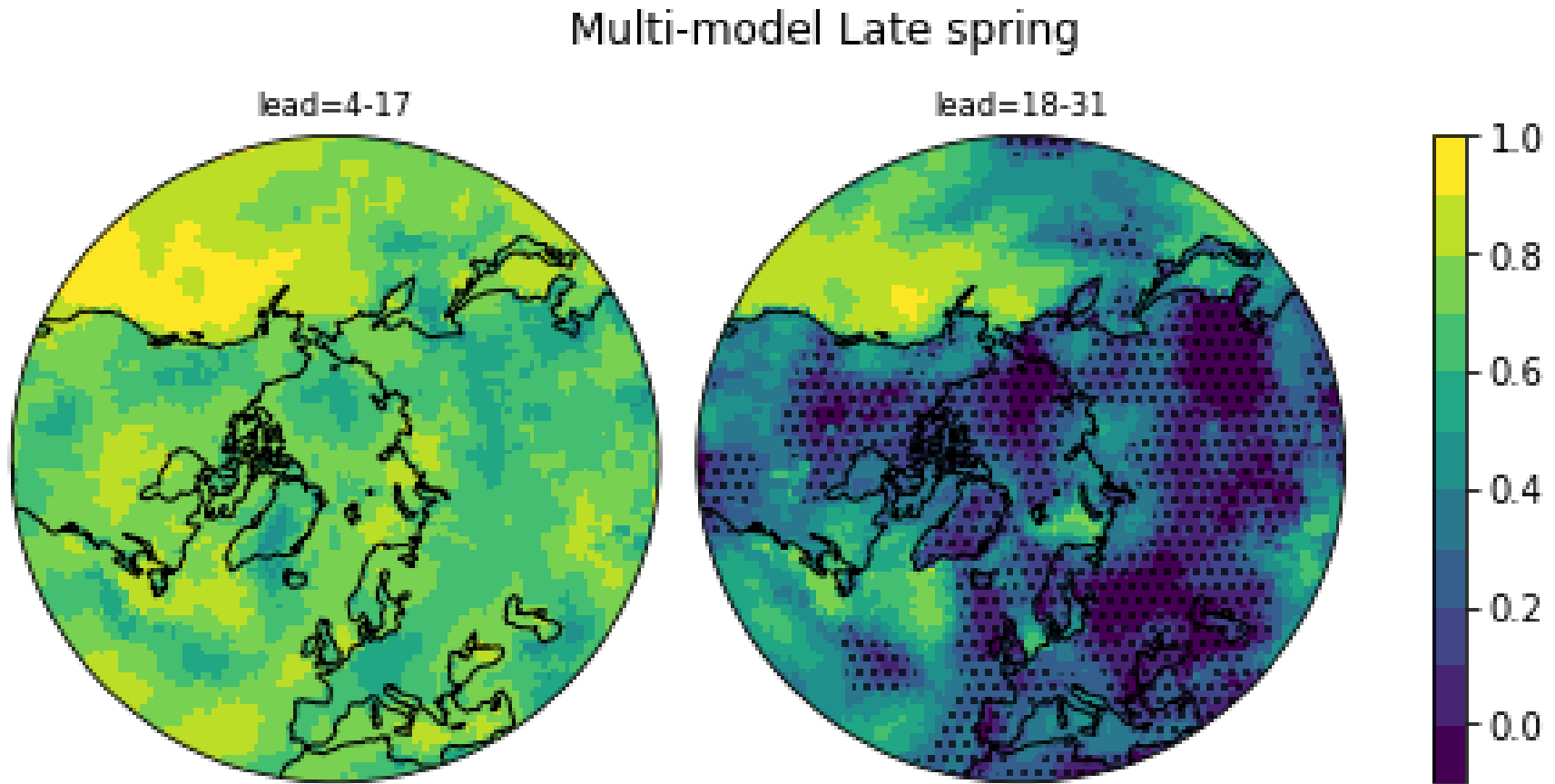
Forecast skill (Pearson correlation) for 2-week-mean 2-m temperatures predicted by a multisystem ensemble. Reference : ERA5
Concatenation of four start dates (~25 Apr, 1 May, 8 May, and 15 May) over 18 years

Could the skill be related to snow cover ?

- **Lagged anomaly correlation** between t2m averaged over the red boxes on Apr. 1st (ERA5) and Snow Water equivalent on March 1st (ERA5-Land), period 1993-2018
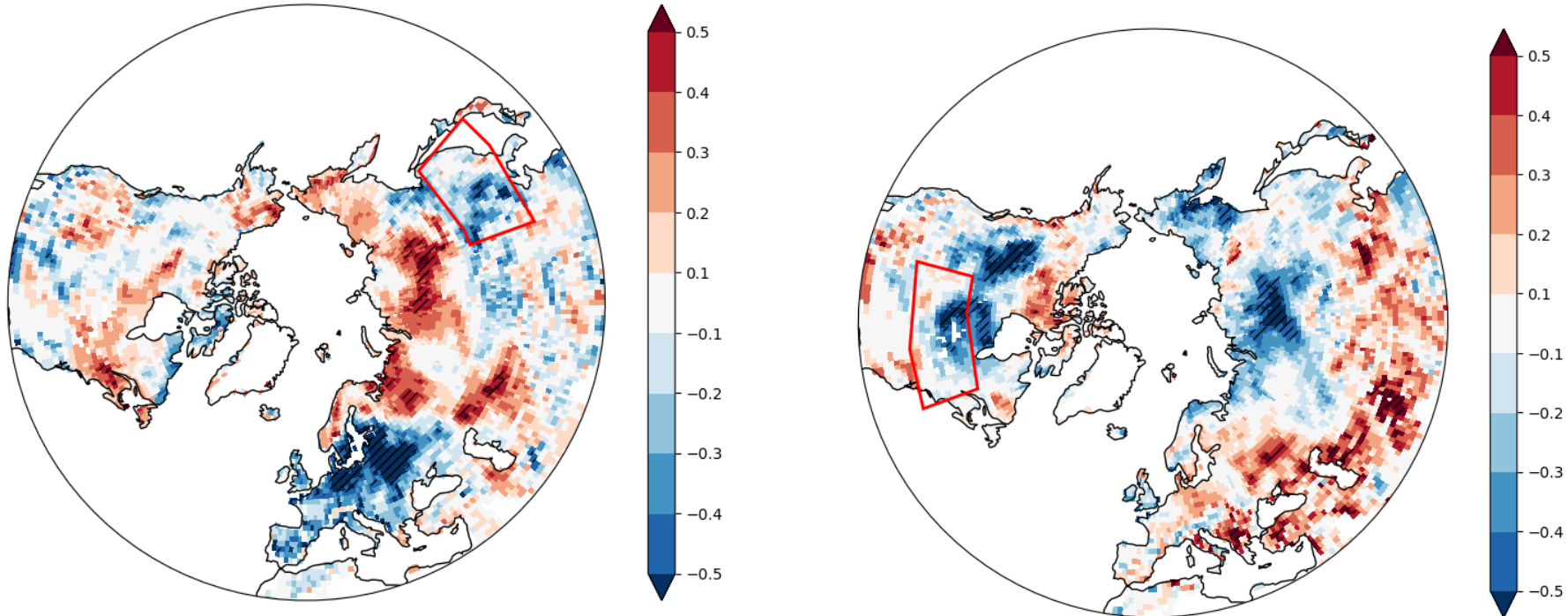
- Correlation ≠ Causality but help define the focus regions

Could the skill be related to snow cover ?

- Computation of SWE Eofs (daily SWE values between mid Feb. and mid March 1993-2018)
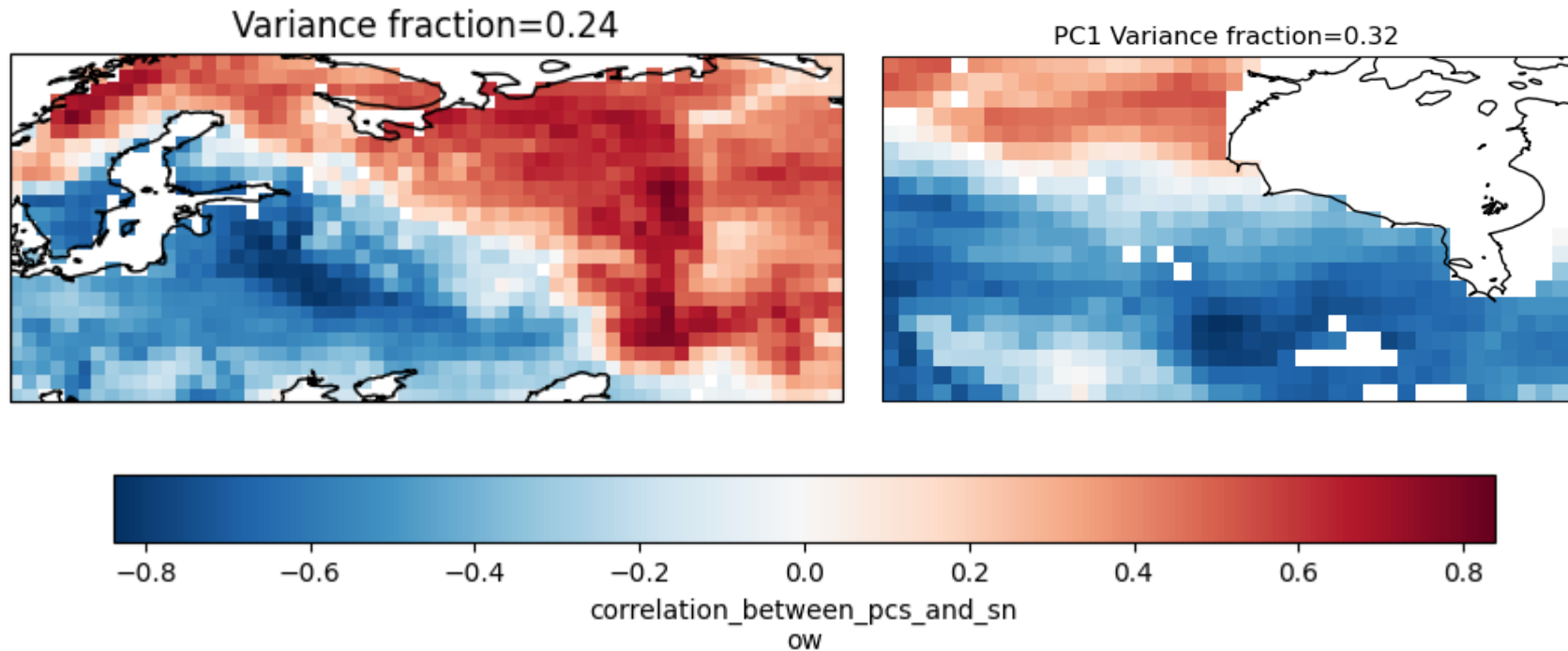
Evaluation over Asia

- Detrended time series of snow pc1 and t2m (left) and z500 (right) averaged over the boxes (1 month lag)
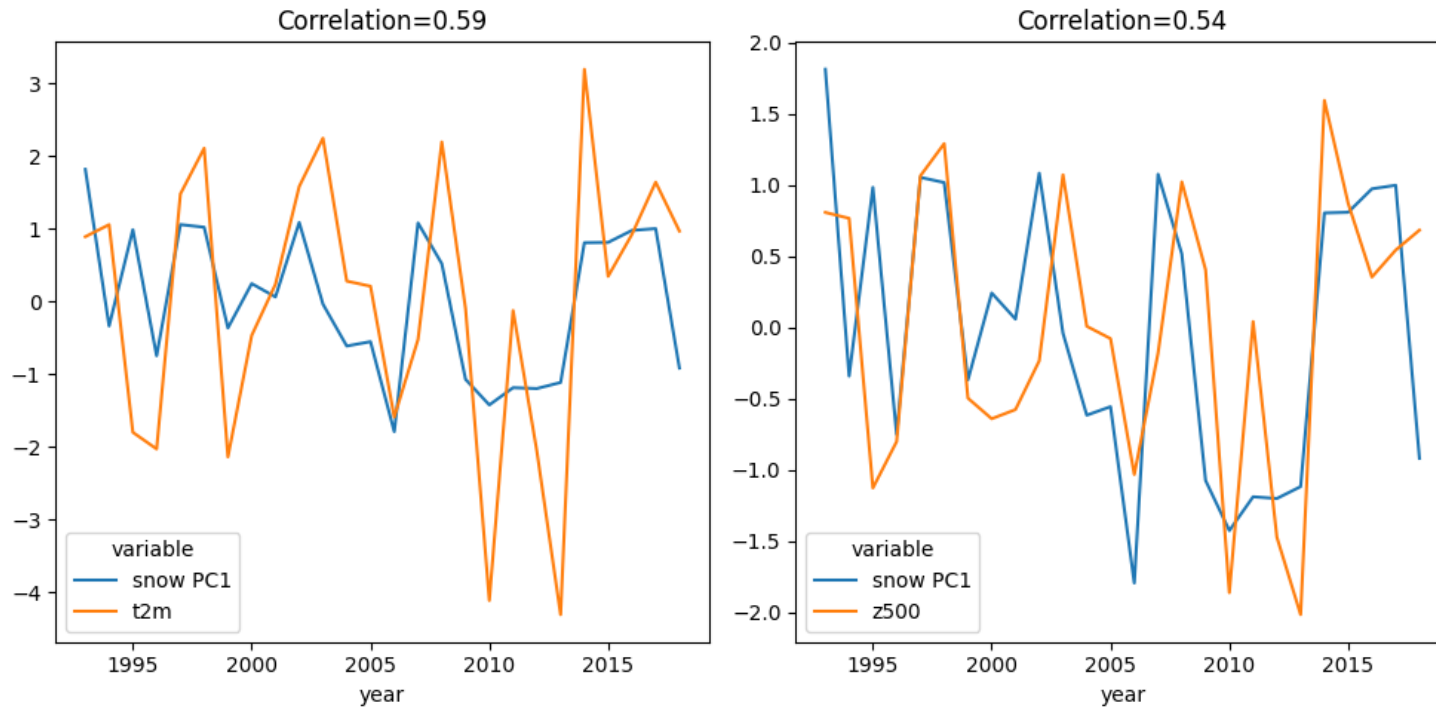
- Correlation of March 1st snow pc1 with April 1st Z500 field
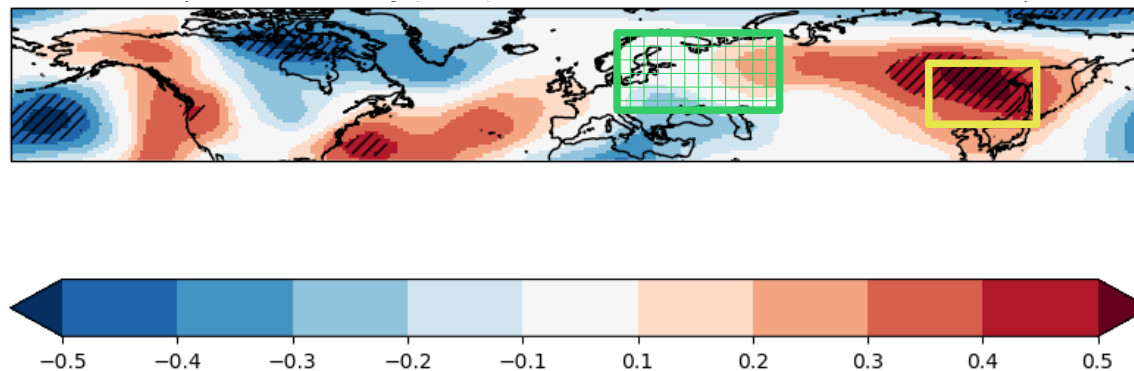
Evaluation over North America

- Detrended time series of snow pc1 and t2m (left) and z500 (right) averaged over the boxes (1 month lag)
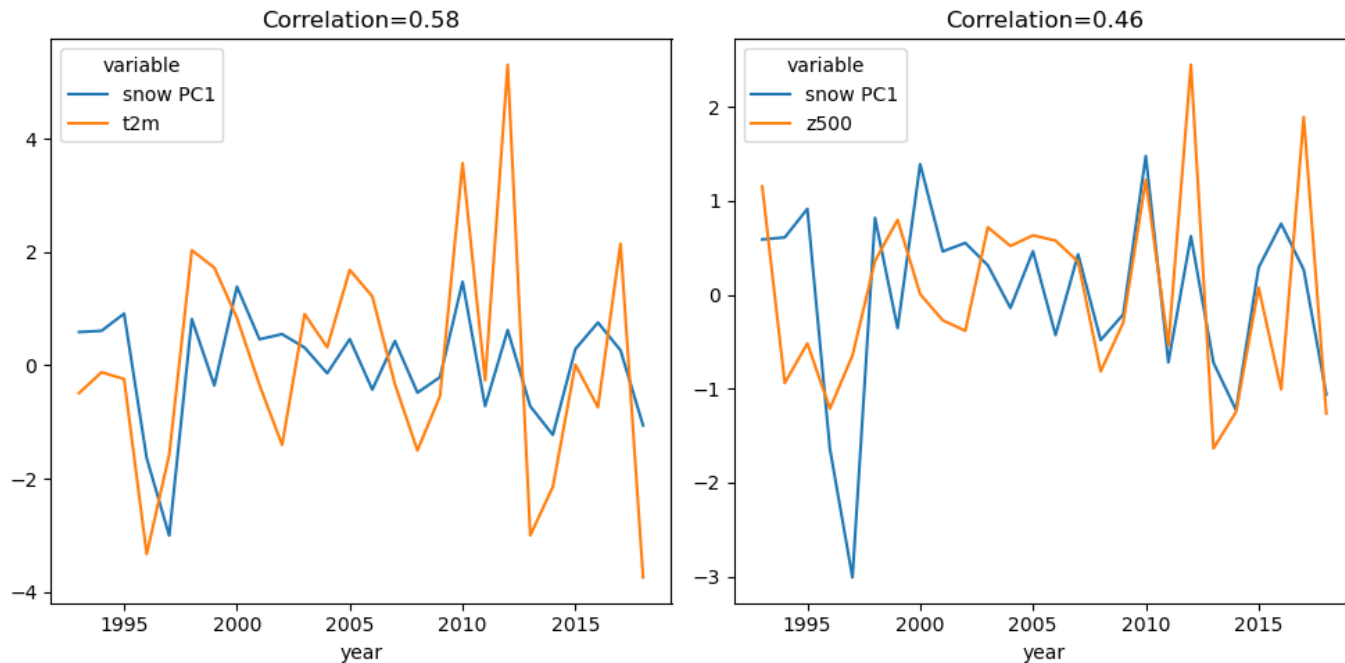
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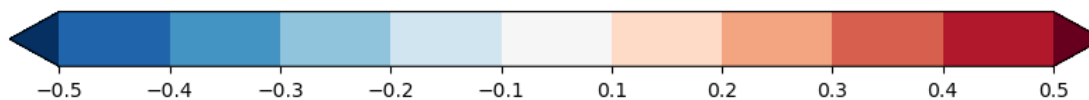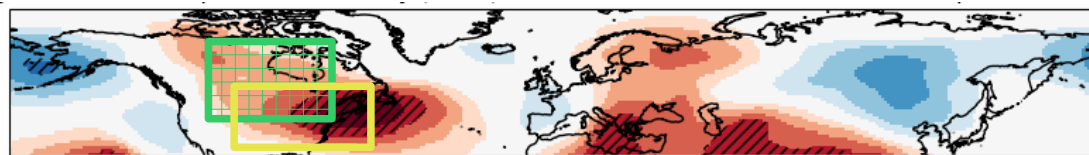
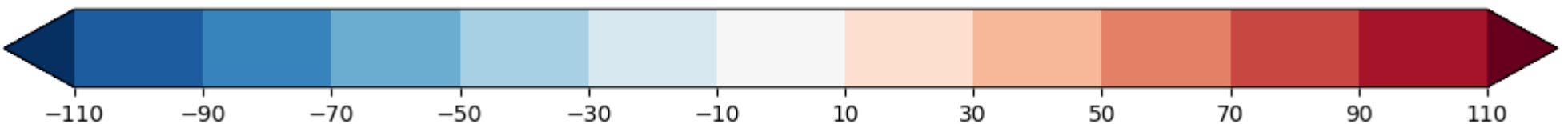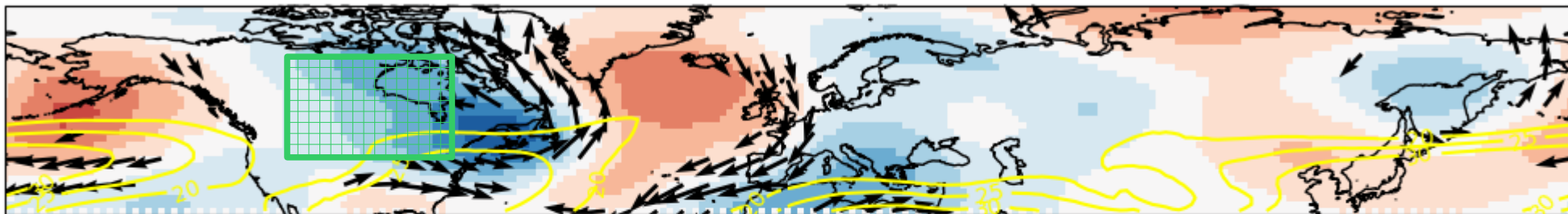# Extension to 1979-2019

- Asia
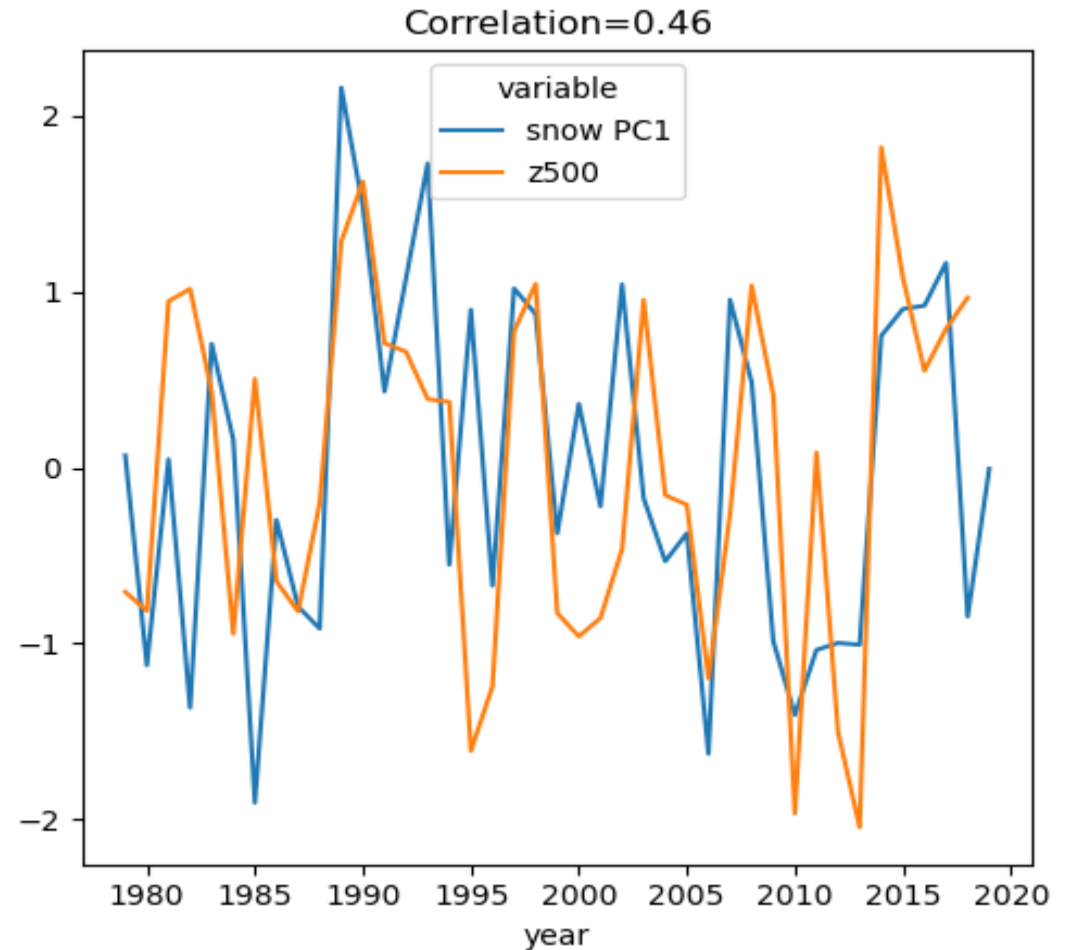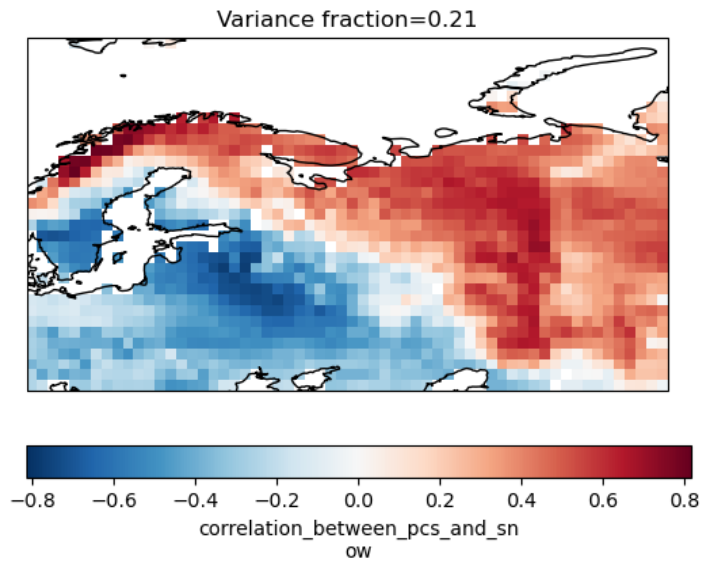
- Subsampling of year with Snow PC1 > 1std, and Snow PC1 < -1std => composite maps

Composite anomalies of Z500 (shades), wind at 300 hPa (vectors) and mean zonal wind (yellow contours) for 30-day averages centered around April 1st
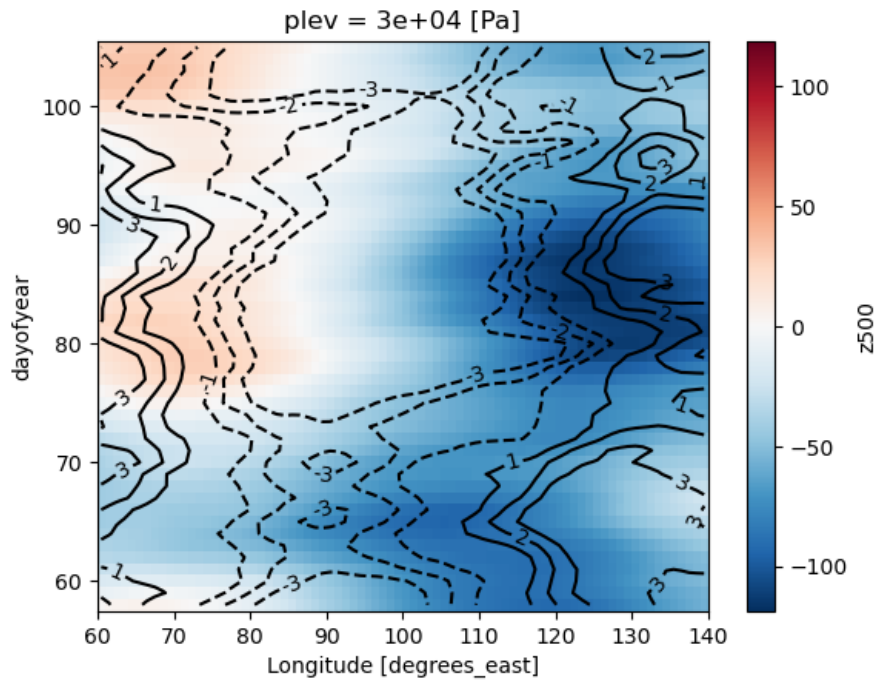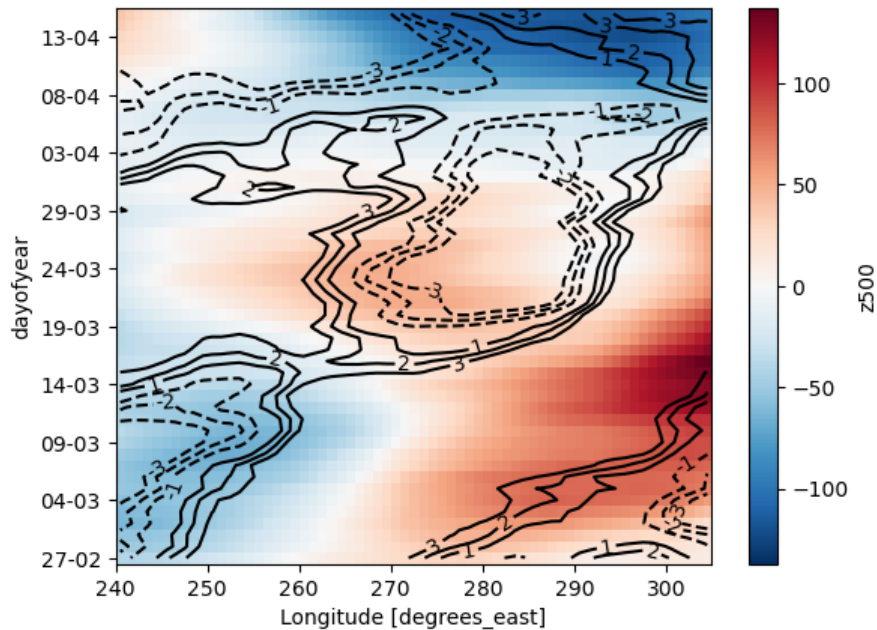
- Asia
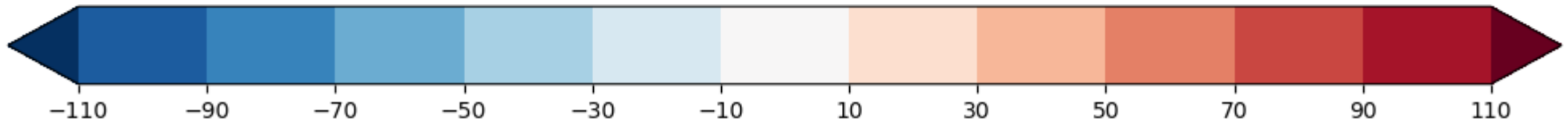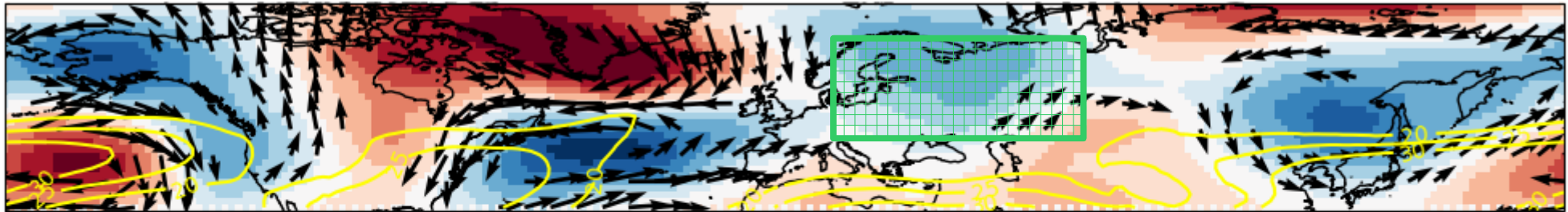
- North America

Hovmoller diagrammes of 14-day rolling mean Z500 (shades), meridional wind at 300 hPa (contours)

- Asia

- North America

Conclusions and way to go

- Main question to address : what are the mechanisms at play for this lagged correlation ?

- Interaction thermodynamics, boundary layer processes and mountain ranges ?

- Is it the same mechanism over Asia and America ?

- If a mechanism is identified, is it well captured by re-forecasts ?

- Many open questions, and current analyses to be completed with sea-level pressure (barotropic anomalies ?) and with T850

- Secondary question : choice of the snow reanalysis : 2 additional slides if interested
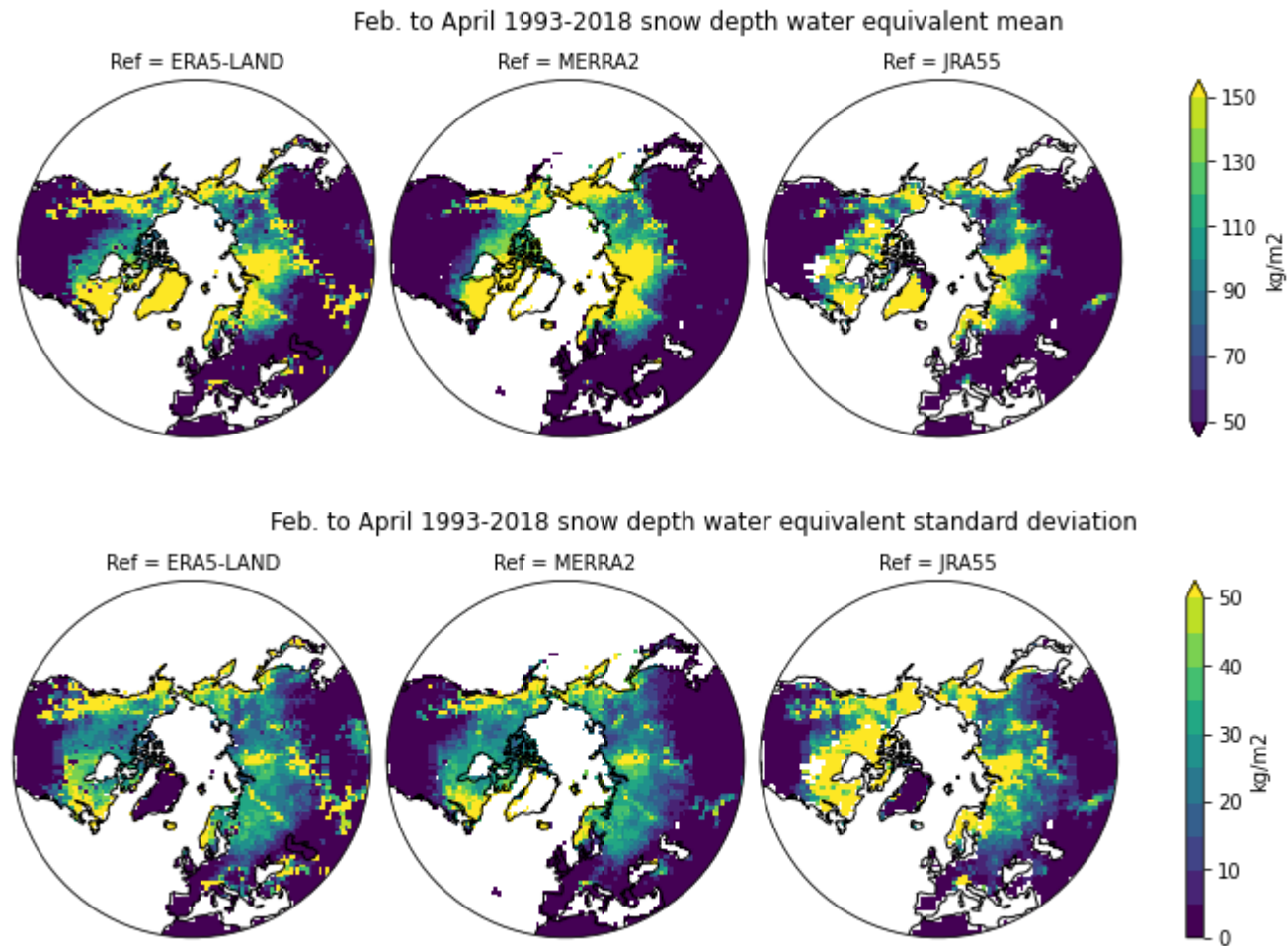
Questions ?
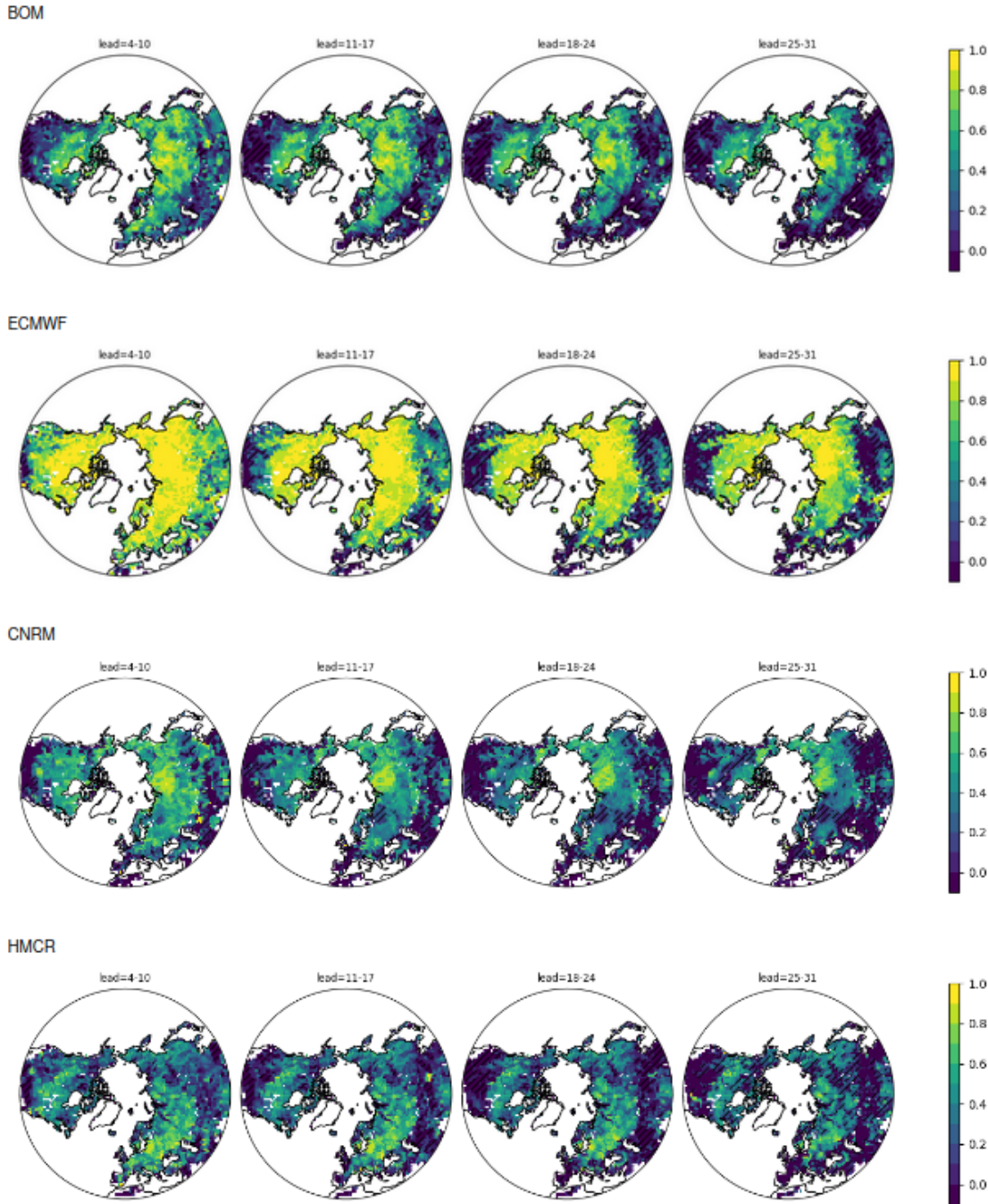
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Questions related to the choice of snow pack renalyses

- How different are they ?

Feb. to April 1993-2018 snow depth water equivalent mean

Feb. to April 1993-2018 snow depth water equivalent standard deviation

- Is ERA5-Land favoring the ECMWF model?

SWE anomaly correlation (ref : ERA5-Land)

Speaks for itself :

- ECMWF far more skillful
- But : similar results with other snow reanalyses