cmcc

Centro Euro-Mediterraneo sui Cambiamenti Climatici

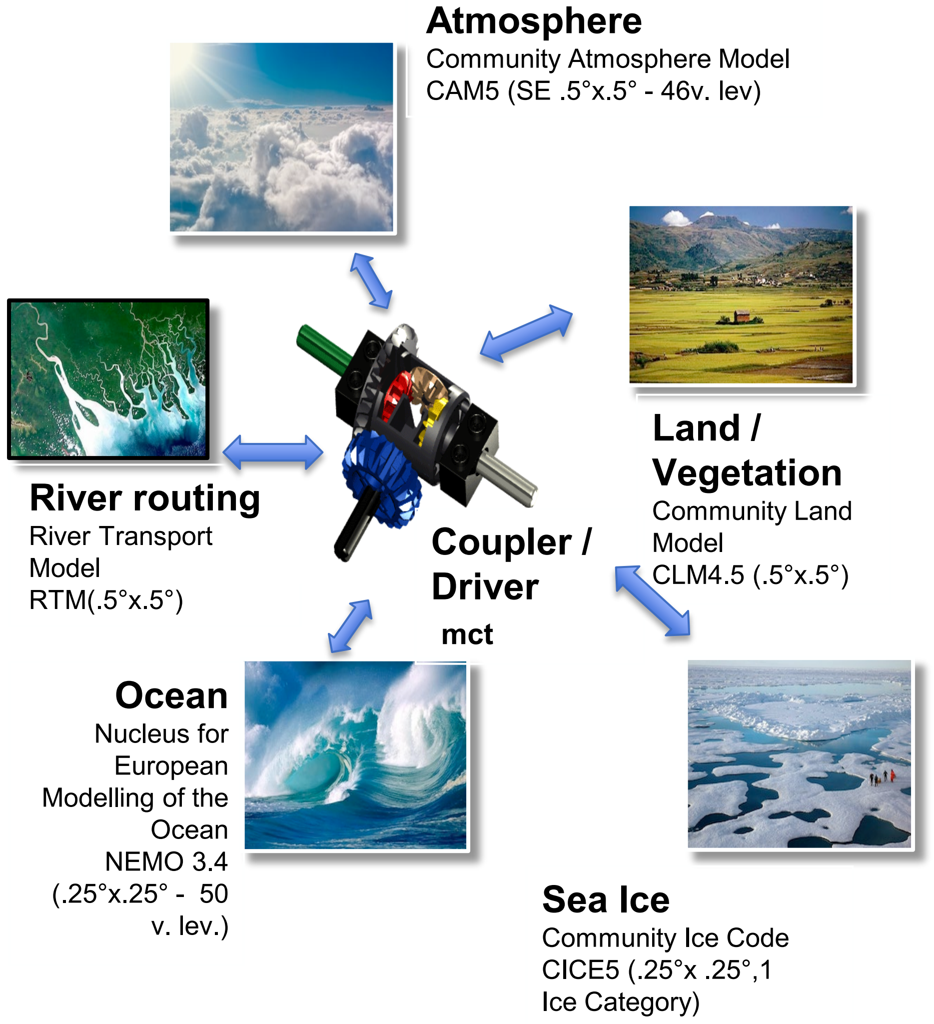
Status of CMCC Seasonal Prediction System and Future Plans for Snow Depth verification

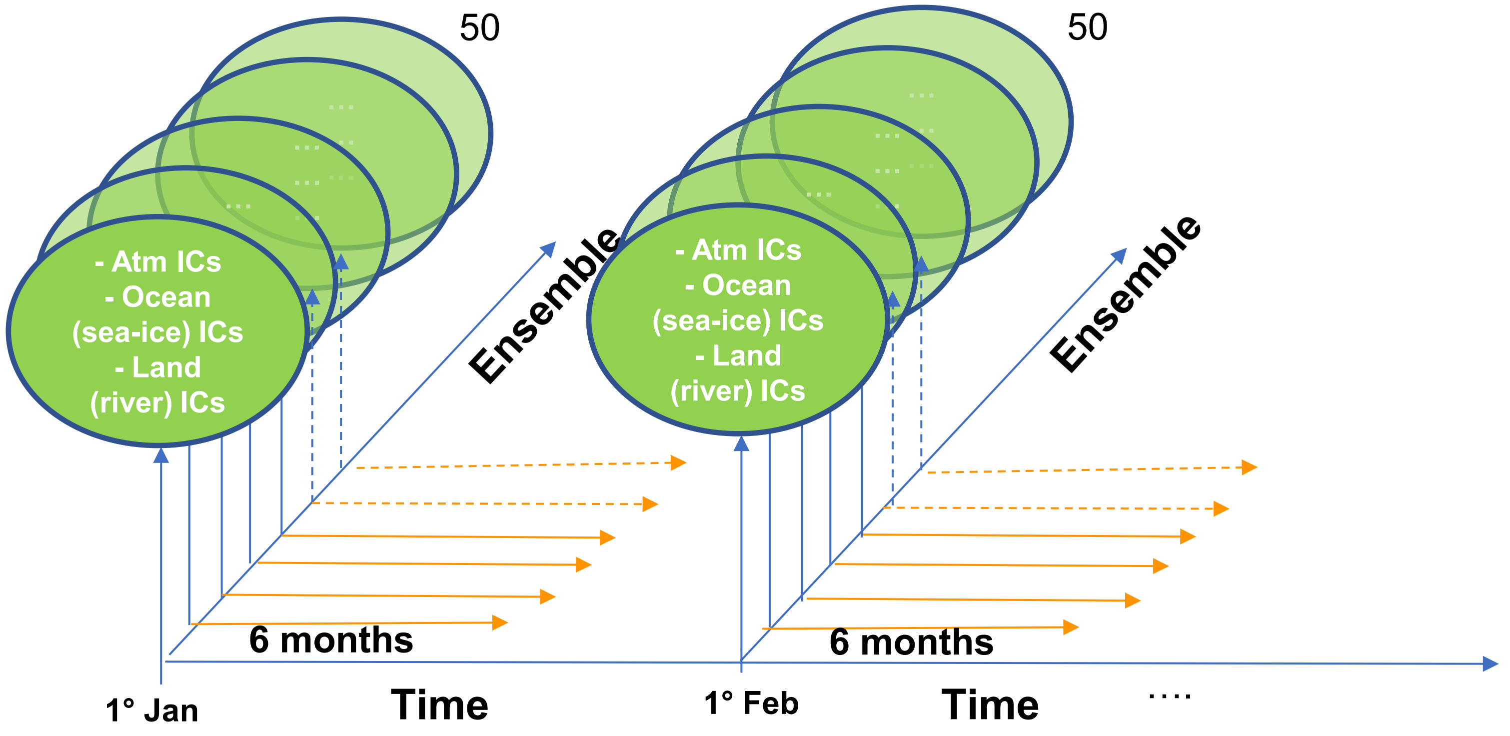
Marianna Benassi, ***on behalf of CMCC-SPS team***

CMCC in the Seasonal Prediction Framework

- ✓ from January 2013, CMCC produces operational **seasonal forecasts**: each month a new seasonal prediction is issued, covering the following 6 months.
- ✓ from June 2013, CMCC is part of the **Mediterranean Outlook Forum** (MedCOF, as member of the Governing Board).
- ✓ from April 2014, CMCC contributes to the **APCC multi-model ensemble seasonal forecasting** (http://www.apcc21.org/eng/index.jsp).
- ✓ from January 2016, il CMCC entered the **Pre–Operational Phase of the Copernicus C3S multi–model ensemble seasonal forecast system**.
- ✓ from April 2018, CMCC is part of the **Operational Phase of the Copernicus C3S multi–model ensemble seasonal forecast system** (climate.copernicus.eu/seasonal-forecasts).
- ✓ since 2021 CMCC is a **WMO-Global Producing Center for seasonal forecast**.

Current system: CMCC-SPS3.5





- start date **every month**, the 1st of the month;
- **12 start dates** per year (once a month);
- **Forecasts: 50 ensemble members** each start date;
- **Hindcasts**: **40 ensemble members** (hindcast period **1993-2016**).

CMCC-SPS3.5 Initialization Strategy

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• **Ten (10) atmospheric I.C.s** are prepared starting from 1-day back in time atmospheric states provided by the 10 EDA analyses, interpolated to the CAM grid, then integrated in time in the SPS3.5 system up to the actual forecast start-date (1rst of the month, h: 00:00).

• **Three (3) land state I.C.s** are obtained from the 1-month land analyses performed with CLM forced with 3 different sets of forcing fields (ERA5, GFS and a linear combination of the 2)

• **Perturbed ocean I.C.s are created by generating nine (4) reanalyses** through perturbation of the ocean observations (in the analysis step), perturbation of atmospheric forcing and introduction of stochastic physics, in the forecast step.

10 atmospheric ICs (10EDA + 1-day SPS3.5 forecast)

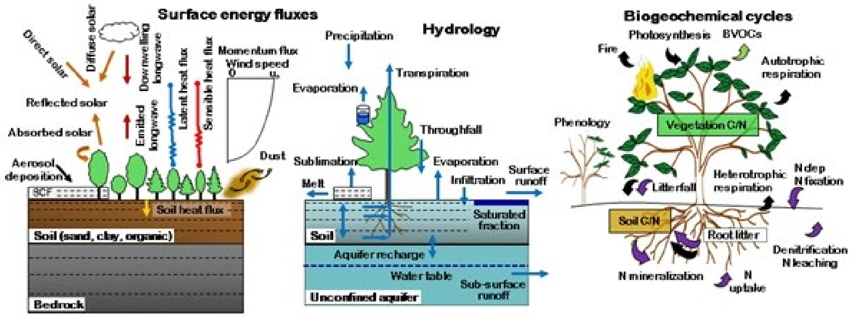
3 CLM4.5 runs forced with **3 different set** of atmospheric forcing as Land Surface ICs

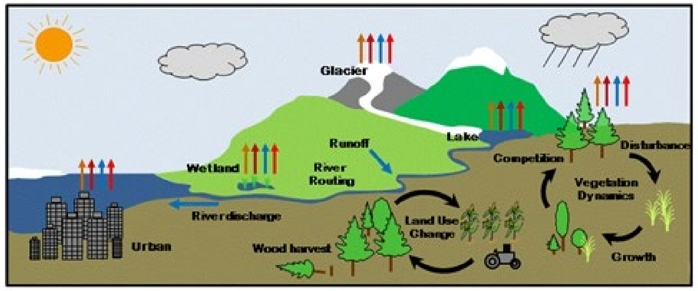
9 (4) ocean analysis resulting from data assimilation

270 (120) ICs

50 forecast members

Land Component Initialization





Land / Vegetation
Community Land Model
CLM4.5 (.5°x.5°)

River routing
River Transport Model
RTM(.5°x.5°)

F(ECMWF,NCEP)

NCEP

ECMWF

Spinup

1993
0201

……..

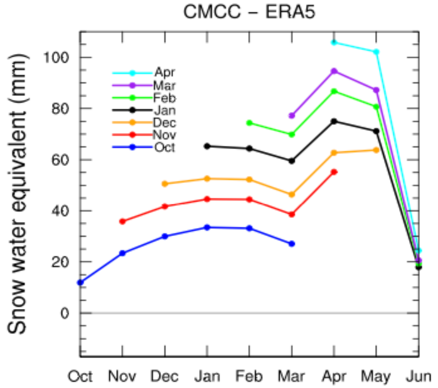
1993
0101

1993
0301

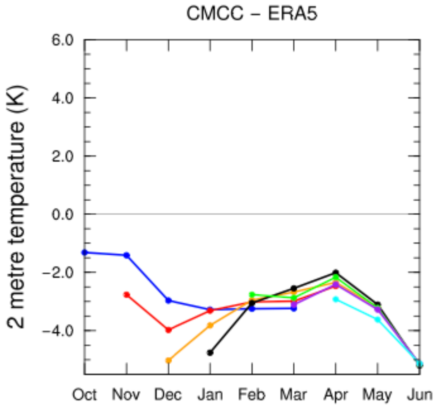
2025
0601

CMCC-SPS3.5 Snow Water Equivalent

Snow Water Equivalent biases over the Siberian region



Excess of SWE over Siberia for all the winter startdates



Cold bias for all winter startdates

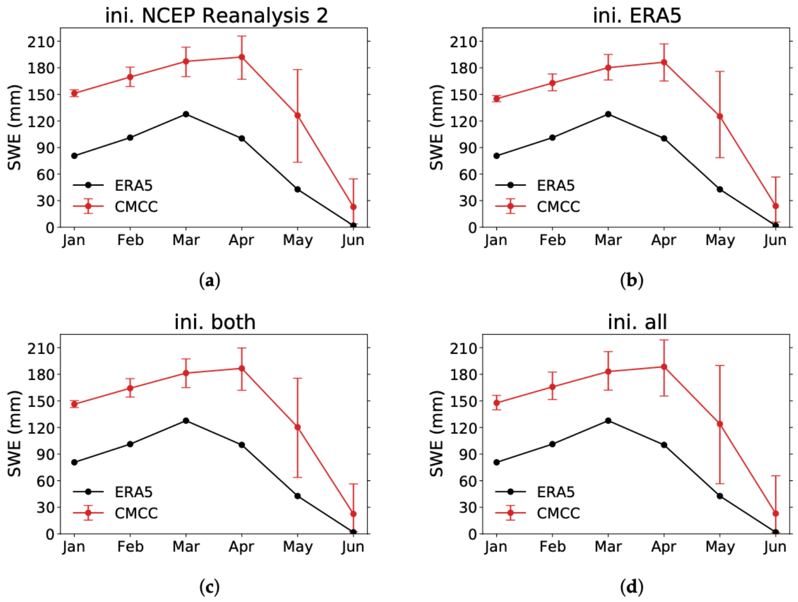
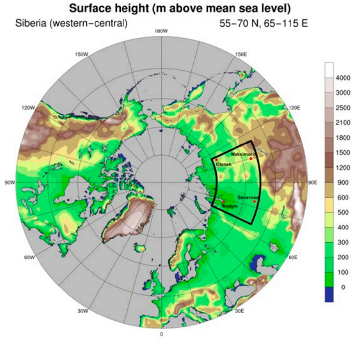


Figure 3. Average monthly SWE from 1993 to 2016 over Siberia from ERA5 (black) and CMCC (red). The red line represents the ensemble mean, and bars show the ensemble minimum and maximum averaged over the years and region. Panel (**a**) shows the sub-ensemble where only NCEP Reanalysis 2 was used to generate the indirect land initial conditions; (**b**) where only ERA5 was used; (**c**) a linear combination of both; and (**d**) the whole ensemble (sum of the previous).

Strong initial biases are independent from the constraining analysis dataset



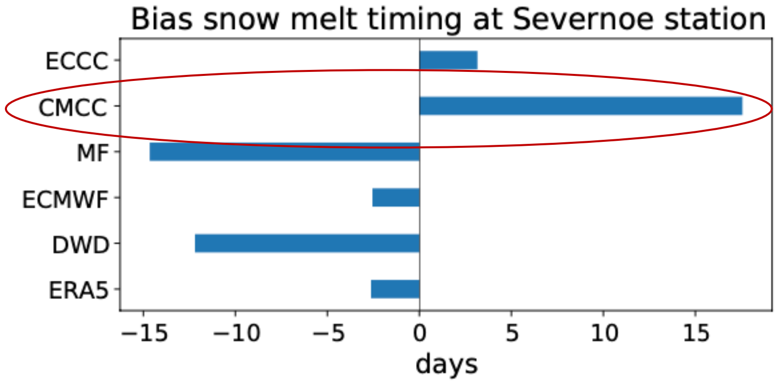


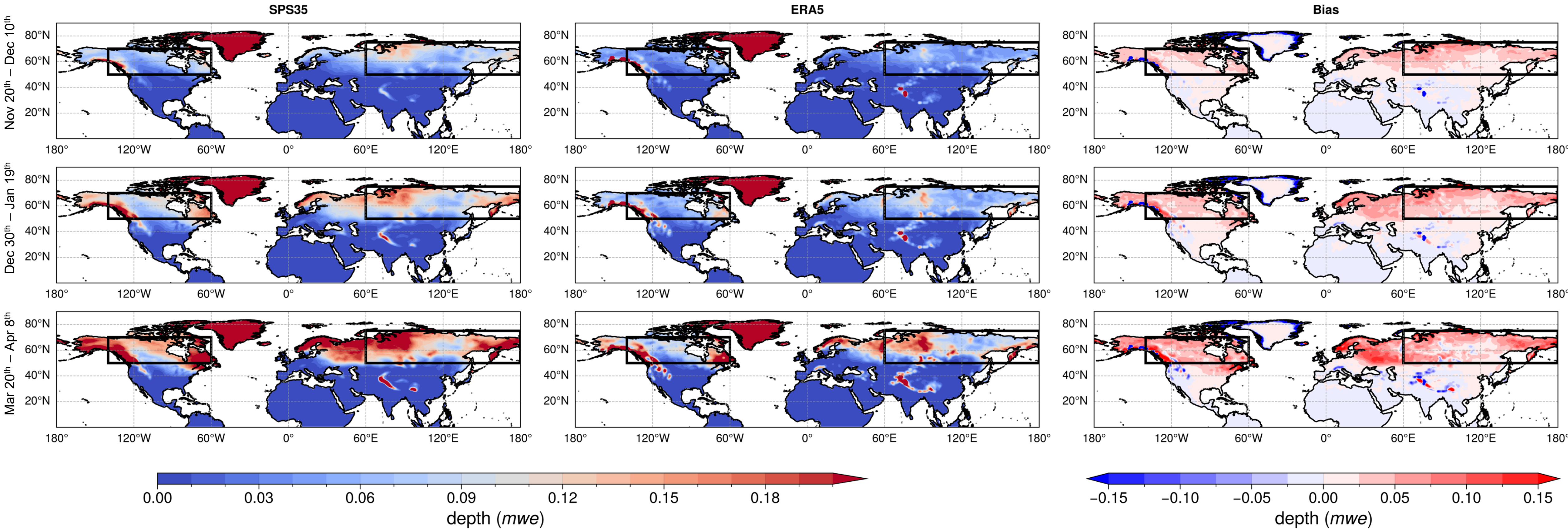
Figure 8. Difference in days of the average melting date at the grid-point closest to the station from the seasonal forecasting systems and ERA5 compared to station data. The melt timing is defined by the time when one-third of the maximum snow depth is left.

Strong biases on start and duration of snowmelt period

Risto et al., 2022

CMCC-SPS3.5 Snow Water Equivalent

SWE full fields and bias – November initialization – CMCC-SPS3.5 vs ERA5

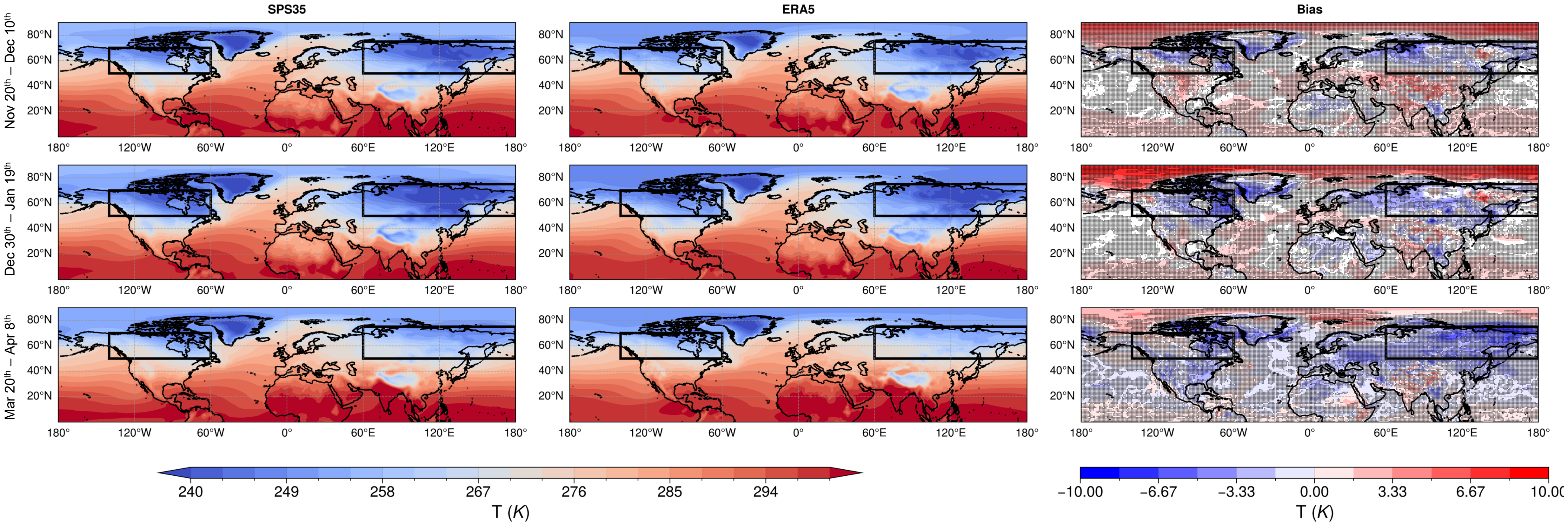


Positive bias in SWE both over Siberia and over North America (similar representation of local processes).

Conti et al., *in prep.*

CMCC-SPS3.5 Snow Water Equivalent

T2m full fields and bias – November initialization – CMCC-SPS3.5 vs ERA5



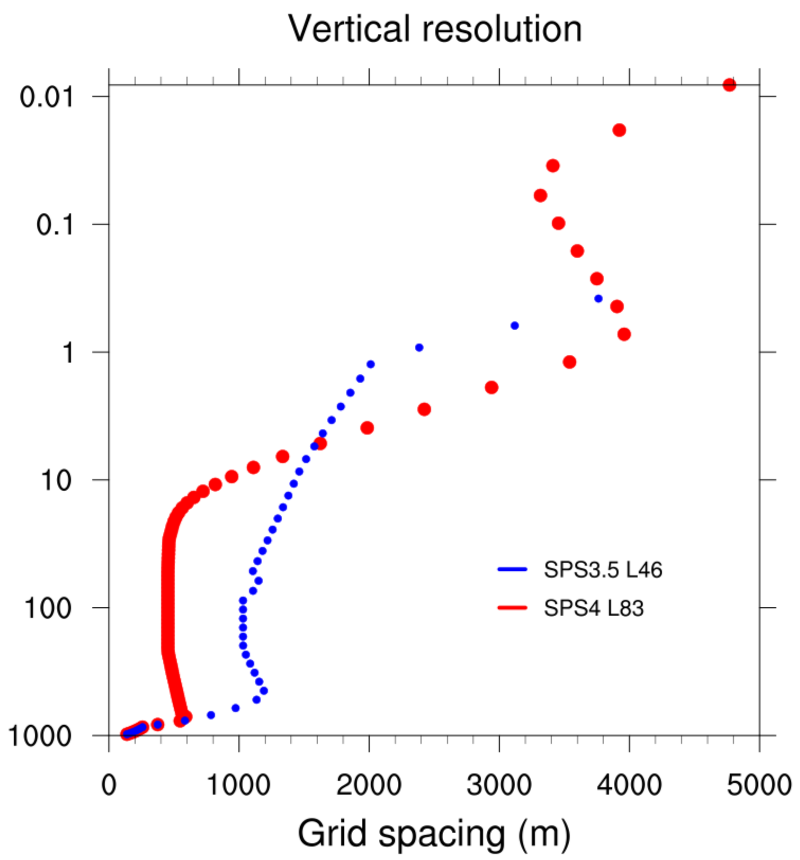
Positive bias in SWE both over Siberia and over North America (similar representation of local processes).
Differently from the Siberian region, over North America no cold biases are present due to different large-scale dynamics in action.

Conti et al., *in prep.*

New system: CMCC-SPS4

	SPS3.5 (2020–2025)	SPS4 (07/2025)
Ocean	NEMO3.6 .25° x .25° – 50 levs	NEMO4 .25° x .25° – <u>75 vertical levs</u>
Atmos	CAM5.3 .5° x .5° – 46 levs	CAM6 .5° x .5° – <u>83 vertical levs</u> improved stratosphere dyn.
Land	CLM4.5 (SP) + River routing scheme	CLM5 (<u>BGC</u>) + Hydros
Ens. size	50 (40 hindcast)	50 (30 hindcast)
Hindcast period	1993-2016	1993-2022
ICs	Ocean Analysis (CMCC) Atmosphere Analysis (ECMWF) Land Surface Analysis (CMCC)	Ocean <u>and Sea–Ice</u> Analysis (CMCC) Atmosphere Analysis (ECMWF) Land Surface Analysis (CMCC)

- CAM change in vertical resolution



- CAM change in dyn core: SE→FV

CMCC-SPS4 Initialization Strategy

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• **<u>Ten (10) atmospheric I.C.s</u>** are prepared starting from 1-day back in time atmospheric states provided by the 10 EDA analyses, interpolated to the CAM grid, then integrated in time in the SPS4 system up to the actual forecast start-date (1rst of the month, h: 00:00).

10 atmospheric ICs (10EDA + 1-day SPS4 forecast)

• **<u>Three (3) land state I.C.s</u>** are obtained from the 1-month land analyses performed with CLM forced with atmospheric fields from the EDA analyses

3 CLM5 runs forced with **3 EDA** atmospheric forcing as Land Surface ICs

• **<u>Perturbed ocean I.C.s are created by generating nine (4) reanalyses</u>** through perturbation of the ocean observations (in the analysis step), perturbation of atmospheric forcing and introduction of stochastic physics, in the forecast step **with the new Ocean and Sea-Ice Analysis System**

9 (4) ocean analysis resulting from data assimilation

270 (120) ICs

50 forecast members

Future perspectives

CMCC-SPS4 will become operational from July 2025

- ✓ Currently finalizing the hindcast production
- ✓ In CMCC-SPS4 update in land surface component, possibly improving model system performance
- ✓ Assessment on CMCC-SPS4 snow variables to be carried out soon
- ✓ Ongoing effort to develop a land-surface data assimilation system, potentially representing an added-value for CMCC-SPS initialization

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www.cmcc.it

Thanks for the attention