# Application of FESOM in the sea ice section: from process studies to seasonal predictions

‘More plans than work that has been performed – in the transition from NAOSIM to FESOM’

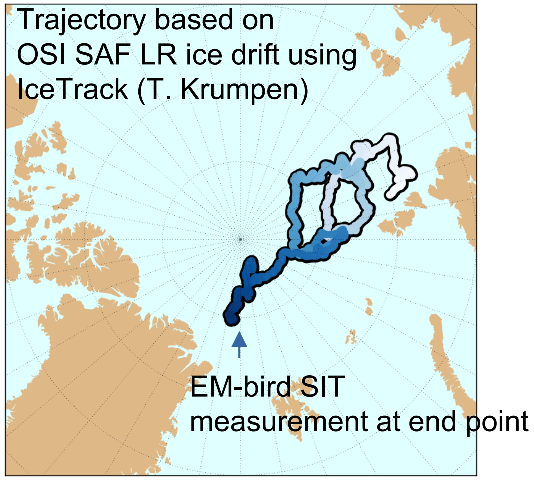
**Outline**

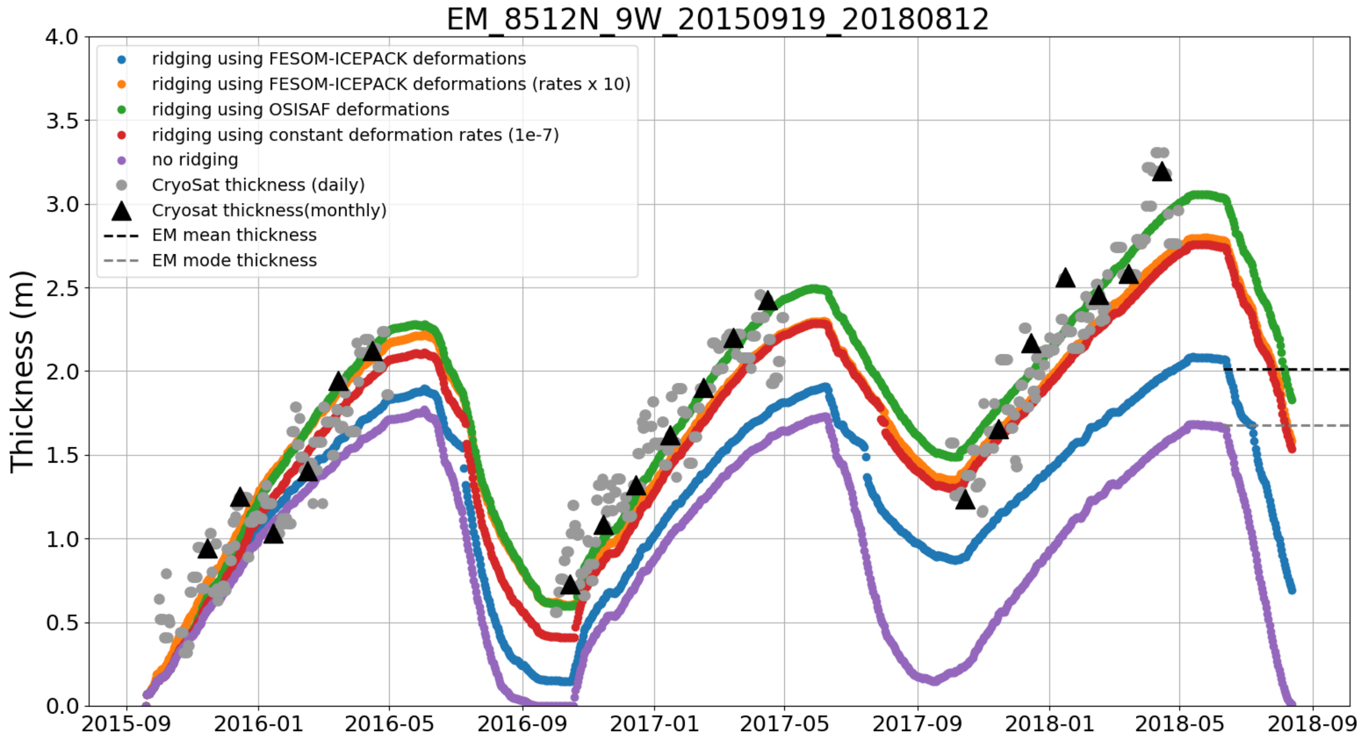
- Taking the most out of in-situ data – 1D Lagrangian modelling (along ‘observed’ sea-ice trajectories)
- Biological modeling (EcoLight)
- Tracer studies
- NRT attribution and seasonal prediction system
- Observation impact assessment – quantitative network design

# 1D Simulation along ‘observed’ sea ice trajectories with ICEPACK

Attempt to get the maximum out of in-situ measurements (MOSAiC: drift, deformation, radiation, melt pond fraction …)

Work performed by Florent Birrien, MOSAiC Postdoc, using ICEPACK in ‘full flavour’ – similar to C3 runs of Lorenzo




- **Knowledge gained will be transferred to FESOM2-ICEPACK (as far as feasible, of course, ‘upscaling’ will be difficult)**

# Two BMBF-MOSAiC proposals regarding 1D modelling

**NuArctic** – on **BGC** coupling ReCom2 and ICEPACK (Lorient Oziel, Judith Hauck, Florent Birrien …)

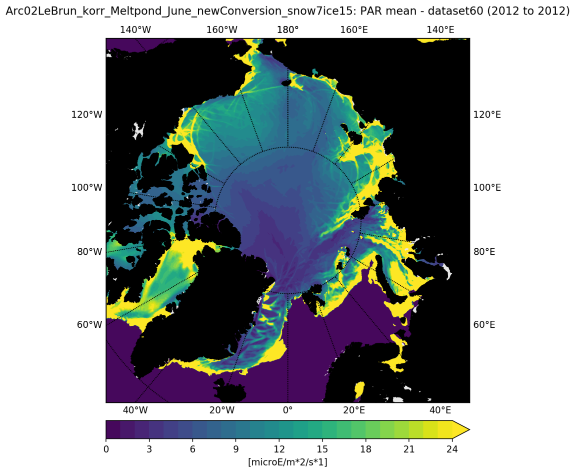
**UNICORN** – on **small-scale vertical mixing** coupling GOTM library to ICEPACK (Kirstin Schulz, Florent Birrien ...)

- **FESOM2-ICEPACK will deliver (lateral) boundary condition**
- **Up-scaling will be a difficult task!**
- **Knowledge gained will be transferred to FESOM2-ICEPACK**

## Ecolight project (NERC/BMBF CAO)

'Ecosystem functions controlled by sea ice and light in a changing Arctic'

- currently: FESOM1.4-REcoM2-SIMBA
- 2021 desired: FESOM2-ICEPACK-REcoM2-SIMBA2



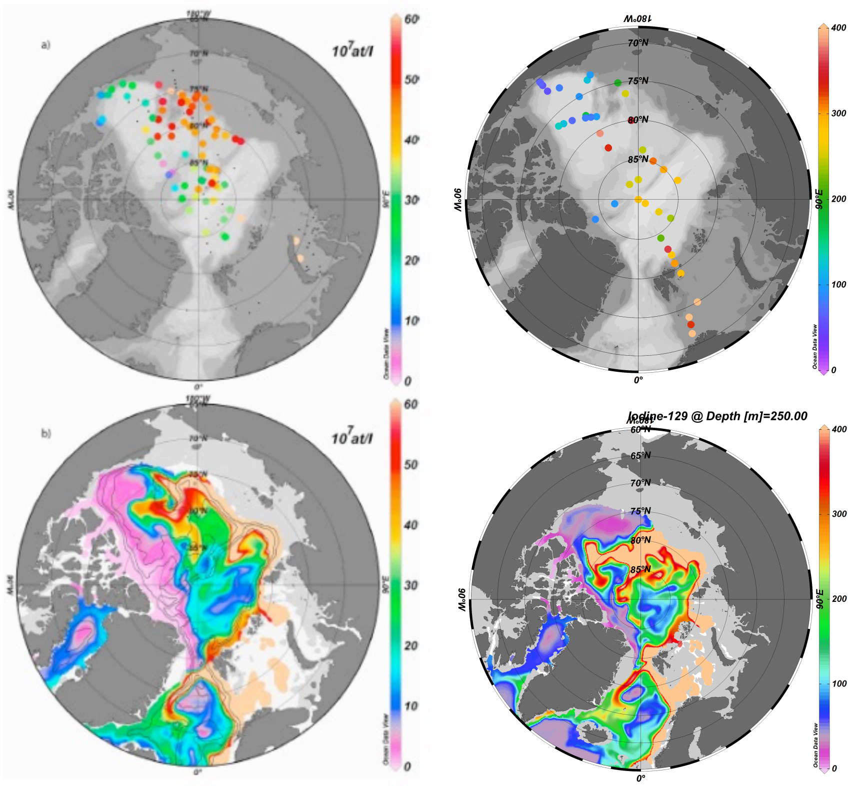

Under-ice PAR
April 2012

## Using observed transient tracers to track changing circulation in the Arctic

e.g. $^{129}I$, $^{236}U$ (conservative, passive)

- capture decadal scale changes of circulation (now developing into a tracer for the AMOC!)
- useful for model validation &/or tuning
- complementary information provided than by hydrography
- used successfull for NAOSIM
- 2021 plan to use for FESOM 2 (also useful for model version intercomparison)

1995 $^{129}I$ 2015




Obs

NAOSIM

Karcher et al., 2012; Smith et al., in rev

## DFG Proposal 'ArcMod'

'The New Arctic Ocean – Understanding processes and consequences of **water mass modification in the inflow regions** in times of rapid change' (Karcher/Spreen), collab with Phys Oc (vAppen) & Clim Dyn (Wang)

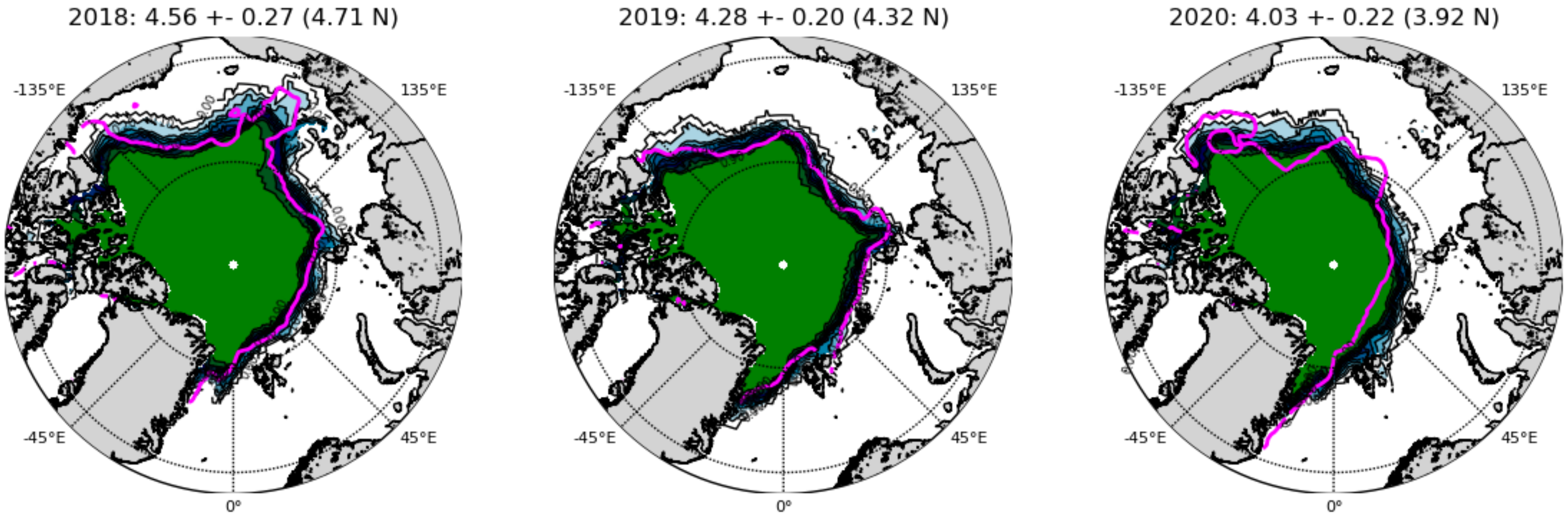
- use of FESOM2-ICEPACK

# NRT Attribution and seasonal forecasting system around FESOM2(-ICEPACK)

## Benefit of CS-2 SIT (AWI) assimilation in March/April on seasonal sea-ice forecasts

- July Arcus SIO 2018, 2019, **2020 –** here, outlook tarted beginning of July
- Seasonal prediction of SIC: probability to have larger or equal concentration of 15%
- Based on **NAOSIM/NAOSIMDAS** (model optimized by mGA, Sumata et al., MWR, 2019)

Forecasted September SIE and uncertainty. In brackets NSIDC observation [mill. km2]




Magenta line: observed SIC: 15% isoline OSI SAF 401

*https://www.arcus.org/sipn/sea-ice-outlook*

# NRT Attribution and seasonal forecasting system around FESOM2(-ICEPACK)

## Status of sea ice model in FESOM2 – ready to use?

Clim 2002-2018 ENVISAT/CS2 v2.2, OSI SAF 430/409 (CDR)

F2 STANDARD SIM **4,5km** JRA55

### cost function ###
cost_concn_sum = 287,814
cost_drift_sum = -
cost_Envisat_sum = 39,306
cost_CS2_sum = 277,426
cost_snowt_sum = -
------------------------------------
### mean cost ###
sigma concn = 0.868
sigma_drift = nan
sigma_Envisat = 0.495
sigma_CS2 = 2.390
sigma_snowt = nan

Greens fct F2 ICEPACK **ponds** ERA5 (O3)

### cost function ###
cost_concn_sum = 293,690
cost_drift_sum = -
cost_Envisat_sum = 37,940
cost_CS2_sum = 149,711
cost_snowt_sum = -
------------------------------------
### mean cost ###
sigma concn = 0.886
sigma_drift = nan
sigma_Envisat = 0.478
sigma_CS2 = 1.295
sigma_snowt = nan

F2 STANDARD SIM NCEP-CFS R/v2 **opt-8 scaledIS**

### cost function ###
cost_concn_sum = 247,841
cost_drift_sum = -
cost_Envisat_sum = 37,100
cost_CS2_sum = 122,059
cost_snowt_sum = -
------------------------------------
### mean cost ###
sigma concn = 0.747
sigma_drift = nan
sigma_Envisat = 0.468
sigma_CS2 = 1.051
sigma_snowt = nan

NAOSIM **opt5.3** NCEP-CFS R/v2

### cost function ###
cost_concn_sum = 190,276
cost_drift_sum = -
cost_Envisat_sum = 30,373
cost_CS2_sum = 107,034
cost_snowt_sum = -
------------------------------------
### mean cost ###
sigma concn = 0.744
sigma_drift = nan
sigma_Envisat = 0.419
sigma_CS2 = 1.024
sigma_snowt = nan

**PIOMAS** 2.1 NCEP1

### cost function ###
cost_concn_sum = 179,868
cost_drift_sum = -
cost_Envisat_sum = 31,168
cost_CS2_sum = 100,947
cost_snowt_sum = -
------------------------------------
### mean cost ###
sigma concn = 0.788
sigma_drift = nan
sigma_Envisat = 0.410
sigma_CS2 = 0.920
sigma_snowt = nan

**TOPAZ V4** ERA interim

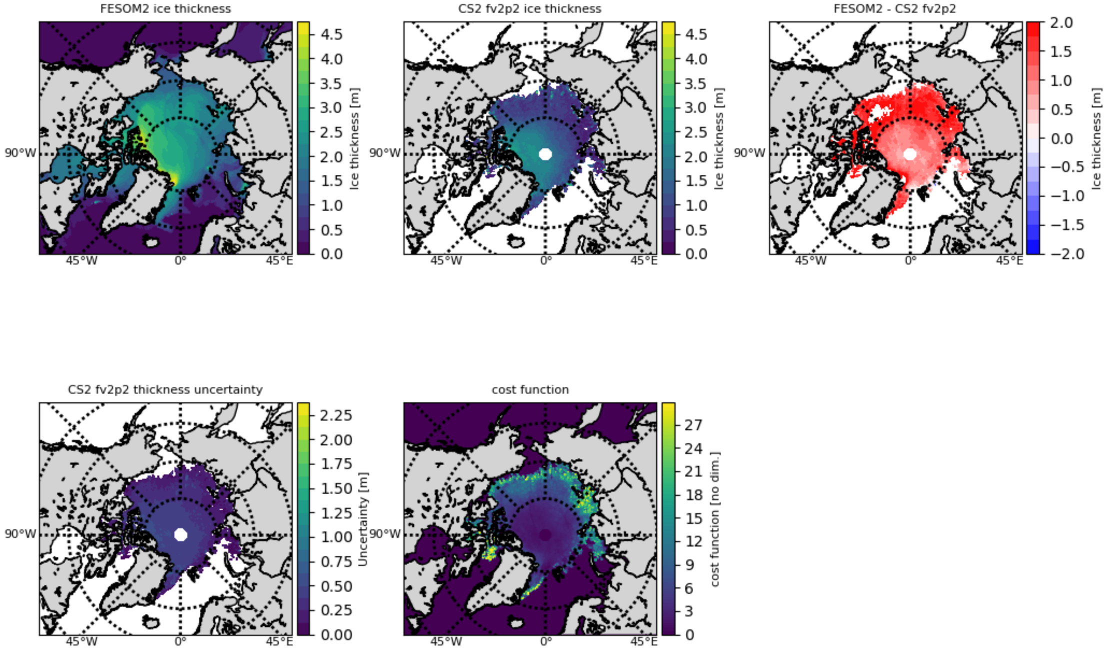
### cost function ###
cost_concn_sum = 173,224
cost_drift_sum = -
cost_Envisat_sum = 41,040
cost_CS2_sum = 158,265
cost_snowt_sum = -
------------------------------------
### mean cost ###
sigma concn = 0.679
sigma_drift = nan
sigma_Envisat = 0.564
sigma_CS2 = 1.481
sigma_snowt = nan

**We have FESOM2 SIM setups suitable for NRT attribution and seasonal prediction system (at least for the Arctic)**

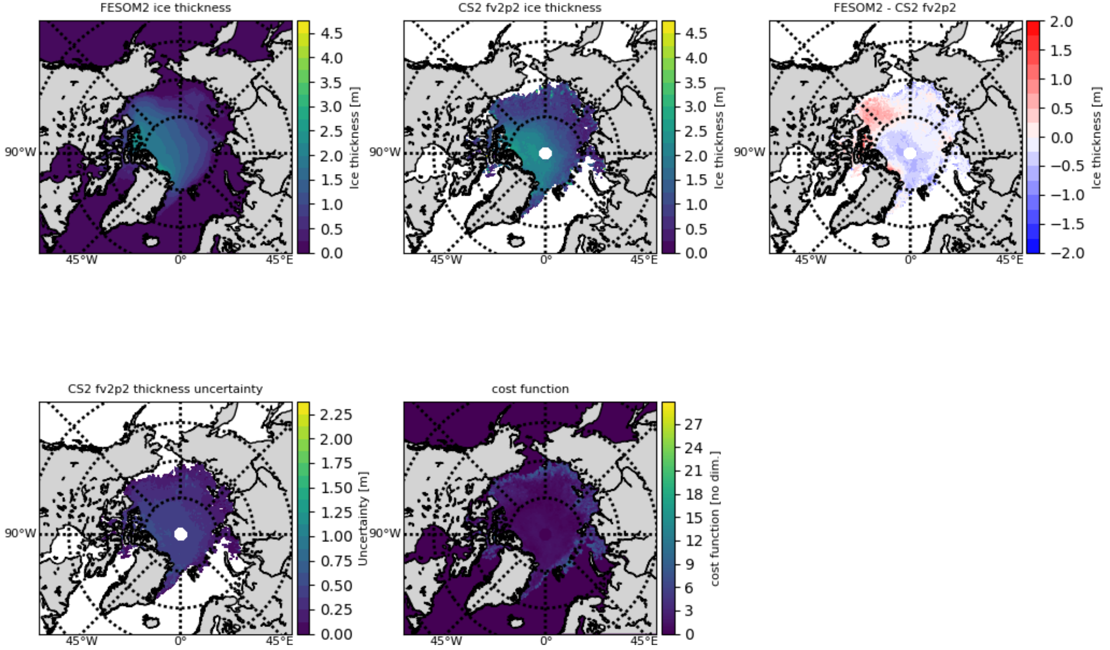
# CS2 SIT October clim

Ice thickness, year =3011, month =10

## F2 HIBLER **FARC** JRA55

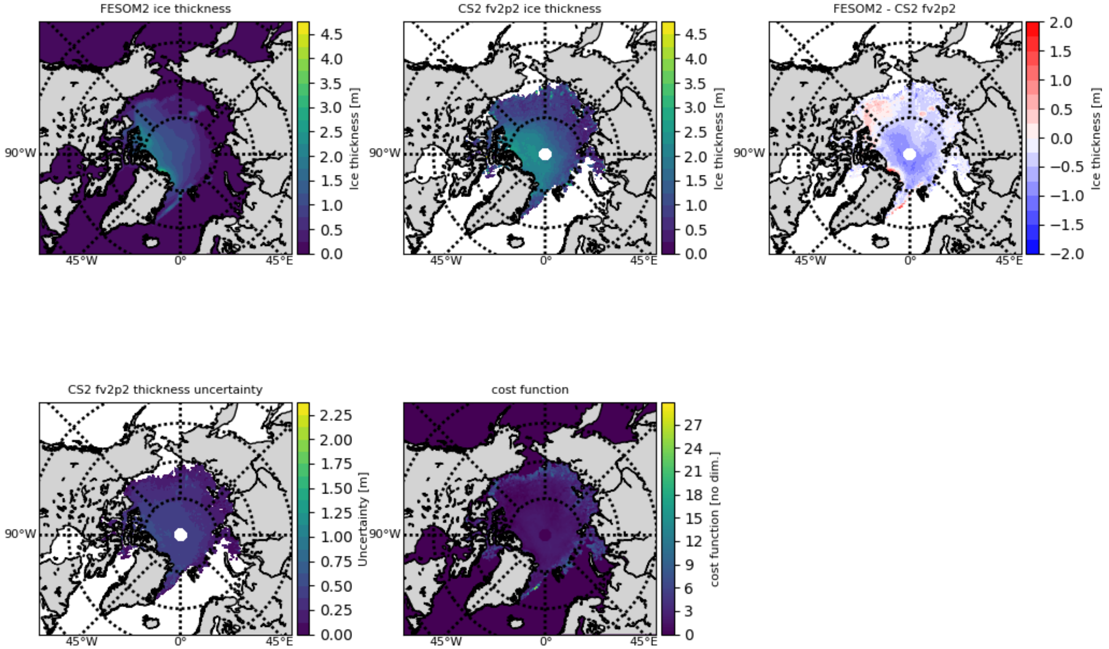



## F2 HIBLER NCEP-CFS R/v2 **opt-8 scaledIS**




Ice thickness, year =3011, month =10

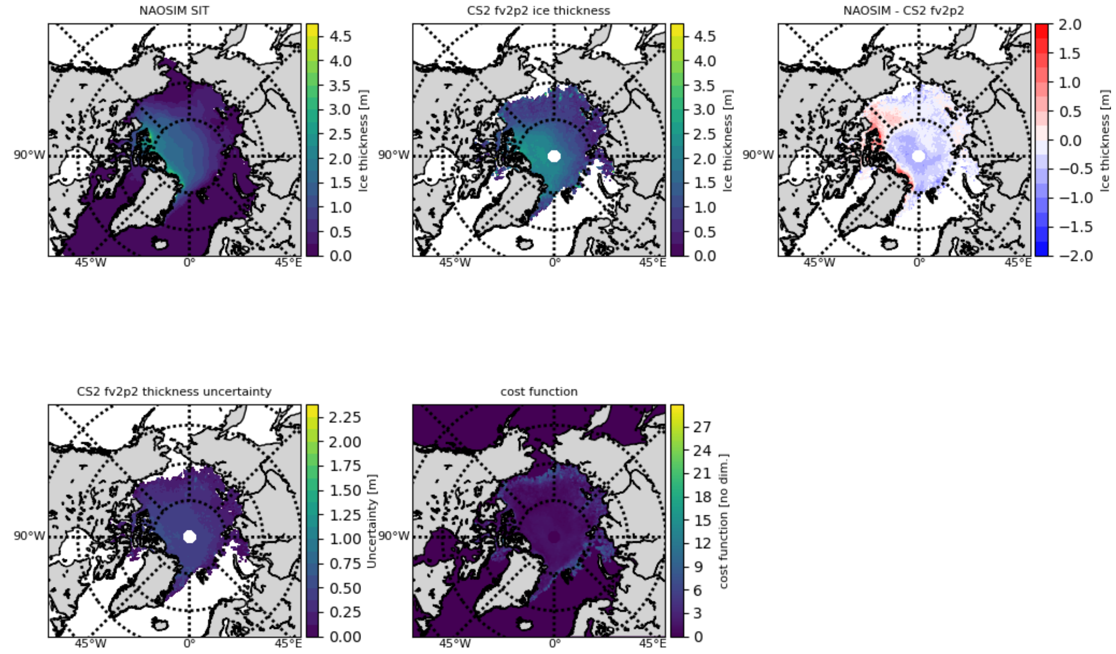
## F2 ICEPACK **ponds** NCEP-CFS R/v2



# CS2 SIT October clim

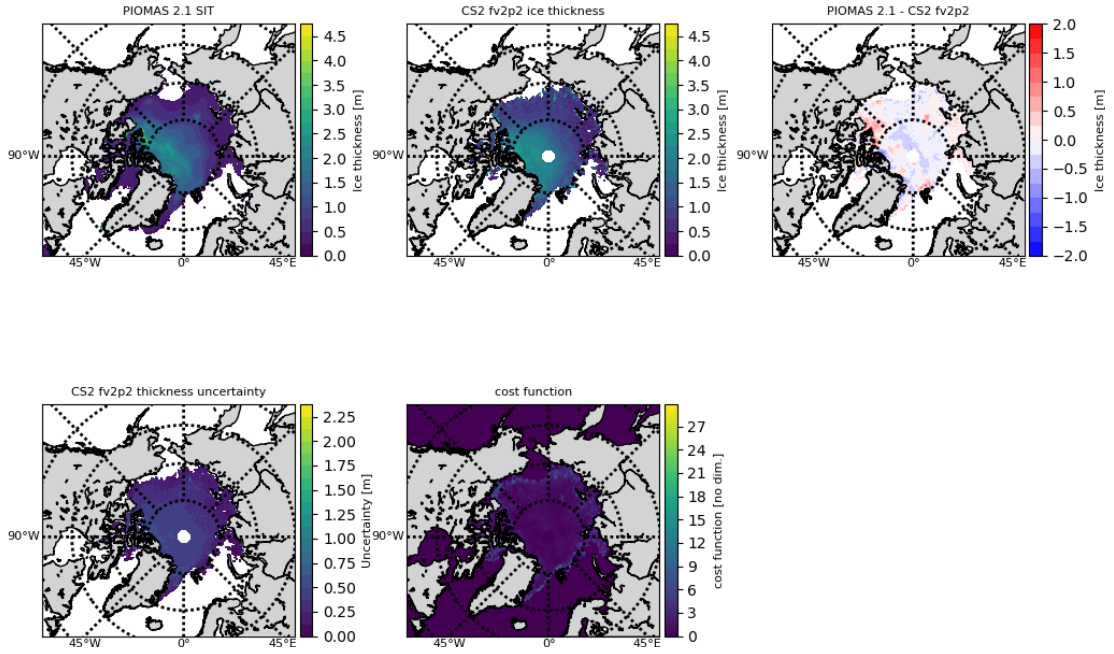
Ice thickness, year =3011, month =10

## NAOSIM **opt5.3** NCEP-CFS R/v2

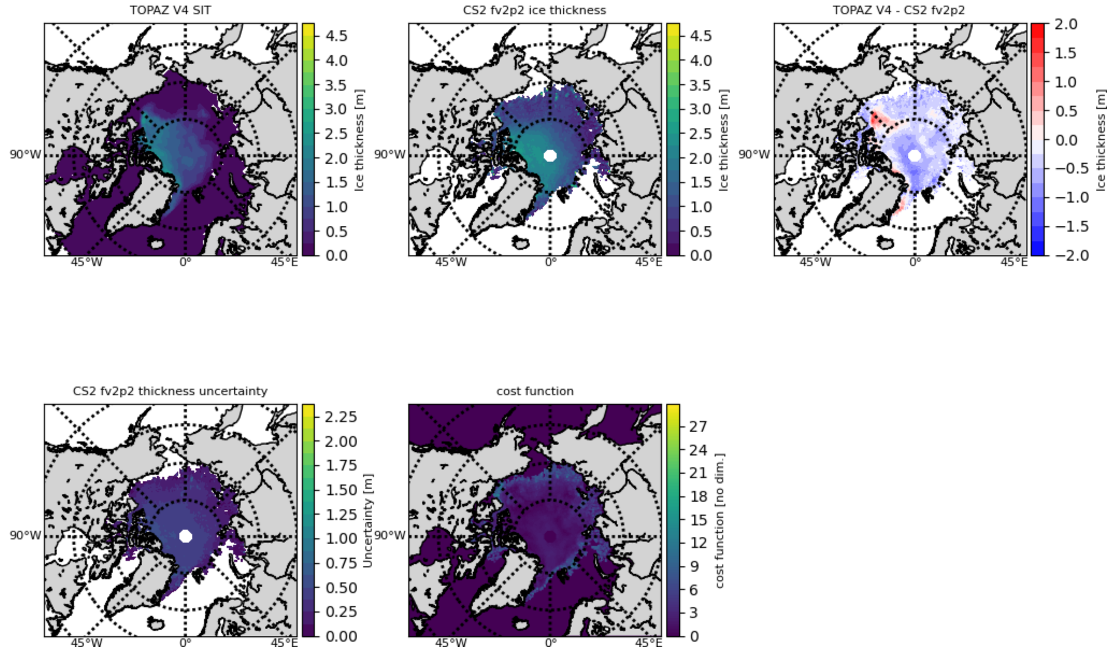



Ice thickness, year =3011, month =10

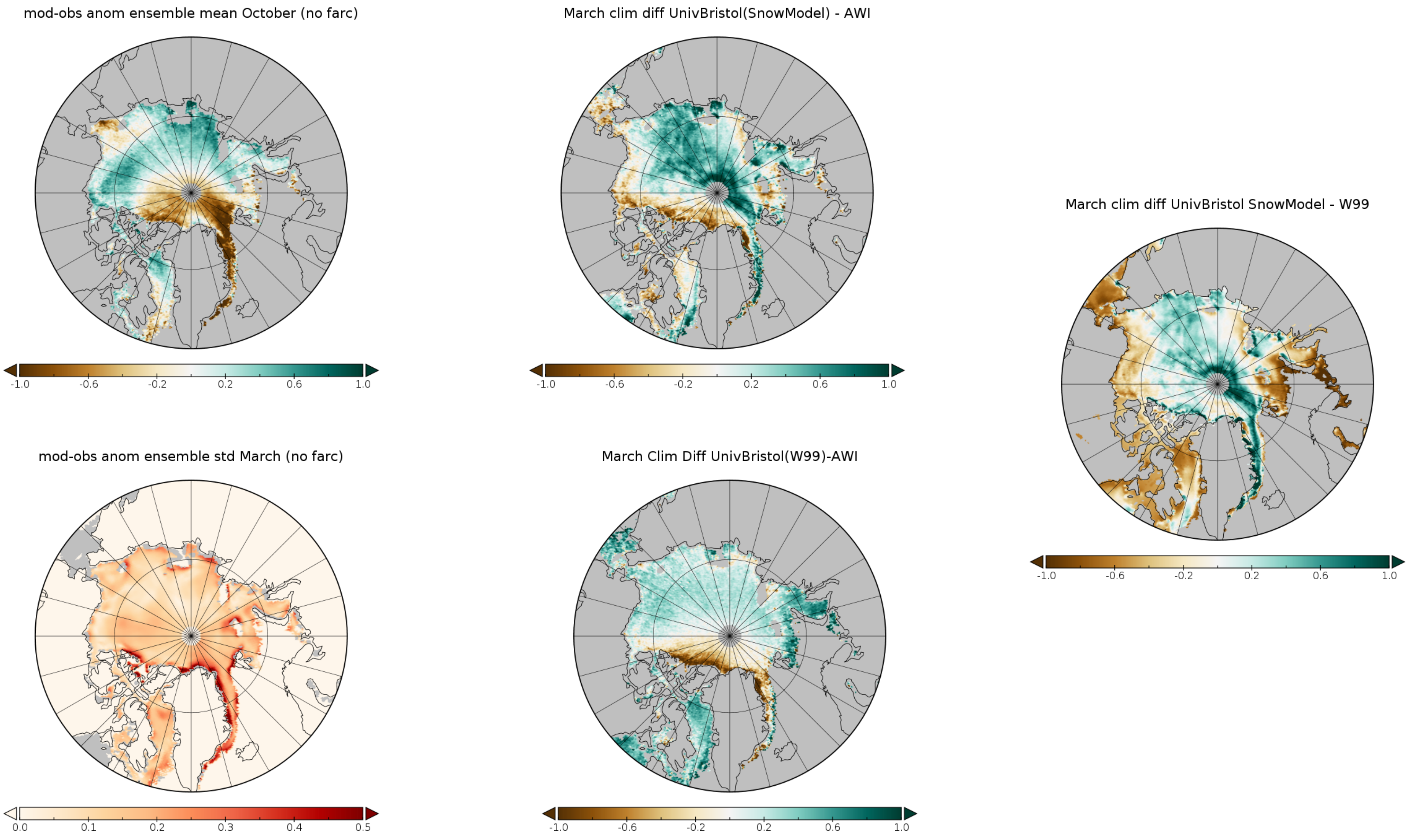
## **PIOMAS** 2.1 NCEP1




## **TOPAZ V4** ERA interim



# March ensemble mean clim. diff. model - CS2 v2.2 **and** UnivBristol (SnowModel, W99) – CS2 v2.2



# NRT Attribution and seasonal forecasting system around FESOM2(-ICEPACK)

**INSPIRE Postdoc for 30 months - will be advertised soon**

- Develop, apply and analyse an attribution and seasonal prediction system
- System will be on a global configuration of the sea ice-ocean model FESOM2 (fesom.de) with high-resolution in polar regions
- Will be designed based on experience gained in the Sea Ice Prediction Network SIPN (https://www.arcus.org/sipn).
- The new system will be initialized with remotely sensed and in-situ observations and will be run quasi-operationally.

You will

- set up the model configuration and operationalize the run scripts
- initialize the system with observations of the sea ice-ocean system employing the Parallel Data Assimilation Framework (pdaf.awi.de)
- assess the attribution system performance for some recent extreme events and analyse the predictive skill
- analyse recent or predicted events of scientific or public interest to better understand the governing processes
- actively disseminate findings to the scientific and public communities, e.g. on meereisportal.de

# Observation impact assessment – quantitative network design

**Studies have been performed with**

- NAOSIMDAS on benefit of idealized ICEBRIDGE in-situ data for marine transportation (Kaminski et al., TC, 2015)
- MPIOM on benefit of (new) EO products on sea ice forecast quality (up to months) (Kaminski et al., TC, 2018) – results from ESA Arctic+ theme 5

Selected output from KEPLER (EU-IP):

Sentinel 3 (S3) radar freeboard (RFB) outperforms CryoSat-2 (CS-2) RFB in the selected target regions relevant for **marine transportation** in the Arctic because of the **higher temporal coverage**. The **larger pole hole** of S3 is irrelevant. While this is trivial for the selected target regions relevant for shipping (too far away), S3 outperforms CS-2 as well for the Arctic-wide assessment which is important for the **sea-ice mass balance**.

**EO project Arctic-Passion currently in review. If successful it is envisaged to use FESOM2(-ICEPACK)**