SICE:
simple sea ice scheme

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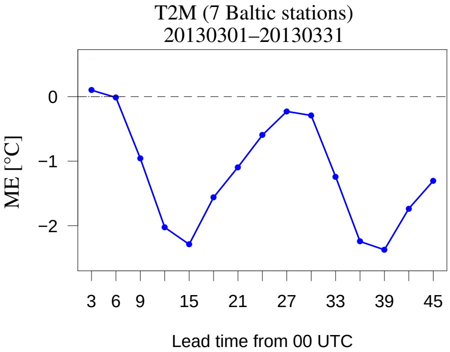
The problem

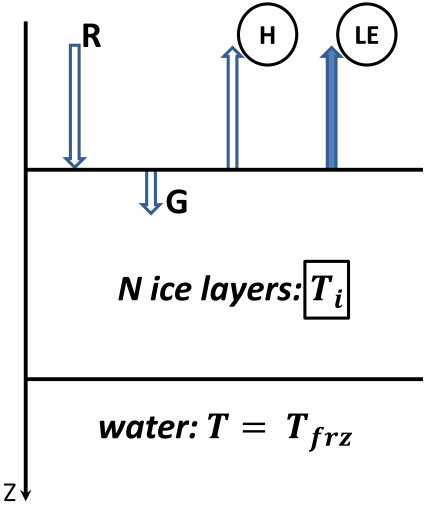


- SURFEX 7 – no sea ice scheme
  - diagnostics only
  - prescribed SST/SIST field
    - in case of operational setup
- HARMONIE in NWP mode
  - SST field from the boundaries
  - SST remains constant during forecast

Possible solutions

- Switch to SURFEX 8
  - \+ advanced sea ice handling (by GELATO)
  - – advanced scheme may require advanced initialization routines
  - – SURFEX 7/8 code bases are not very compatible
- Couple with an external ocean model
  - \+ full strength of external ocean model
  - \+ detailed description of ice processes
  - – computationally heavy
  - – requires more resources for its implementation
- Put an existing sea ice scheme into SURFEX
  - \+ well tested production ready scheme can be used
  - – an external ice scheme may use its own approach for init and output
- Introduce a new sea ice scheme in SURFEX 7
  - \+ minimal affect
  - \+ scheme can be lightweight
  - \+ can be implemented in short time
  - – only partial representation of ice processes

SICE



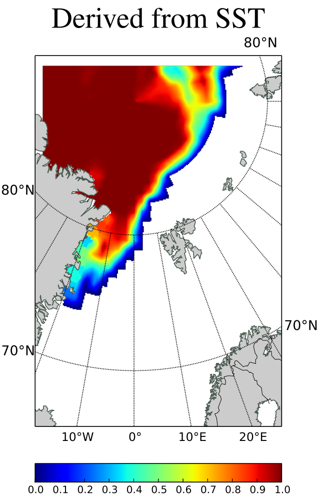
- 1D simplistic ice scheme
- Constant ice thickness
- SIC (SST SIST) driven
- Snow on ice by ISBA ES

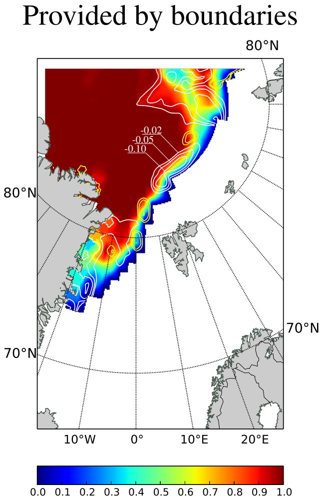
Limitations

- 1D model without any parameterization of ice dynamics
- Prescribed ice thickness
- Scheme is driven by the external ice fraction field
- Snow-free setup is not realistic and causes too warm ice surface
  - but snow-enabled configuration has several problems
- Simplistic initialization procedure
- No assimilation
  - ice scheme runs freely from cycle to cycle

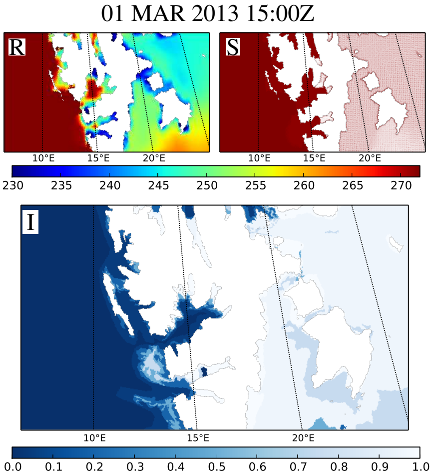
Ice fraction handling

- SURFEX 7 does not use information about the ice fraction
- SICE: ice fraction from the SST field or from an external data source





Ice fraction handling



SST [K] (upper) and SIC (lower)

R – ref run; S – SICE is enabled (white shade – ice covered area)
I – SIC chart by the ice service

- In the reference Harmonie version sea grid cells are filled by T_0 which is affected by land surface temperature

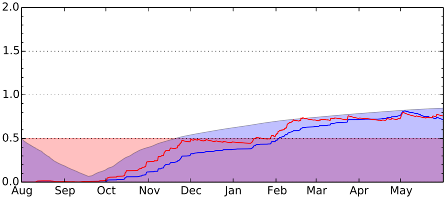
How it's done when SICE is enabled:

- Ocean grid points contains SST only data
- SST and SIC fields are extrapolated to fill gaps
  - Usage of the ice fraction data provided by boundaries requires high spatial resolution of the external SIC data

Snow on ice

- Bare ice and snow enabled setups are available
- No snow fraction
- Simplified representation of the snow-ice interaction processes
- 3L explicit snow scheme
  + Advanced snow scheme
  + Explicit snow approach allows us to use an existing scheme with minimal impact to the existing code base
  – 3L snow scheme in SURFEX 7 is known to have issues and the improved version of 3L scheme from SURFEX 8 should be used instead

Snow on ice



Svalbard airport (2011/2012)
SURFEX HIGHTSI
shade – ice thickness
solid lines – snow thickness

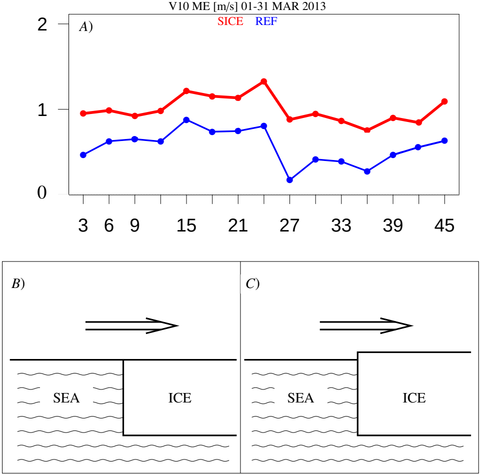
SICE with 3L explicit snow:

- Two PREP options for snow on ice
  - Start from the snow free ice surface
  - Uniform snow field (same for SEA and NATURE tiles)
- Increased minimal value of snow albedo
- Snow accumulation is not limited

HIGHTSI:

- Advanced thermodynamical sea ice model

10 meter wind speed over ice surface

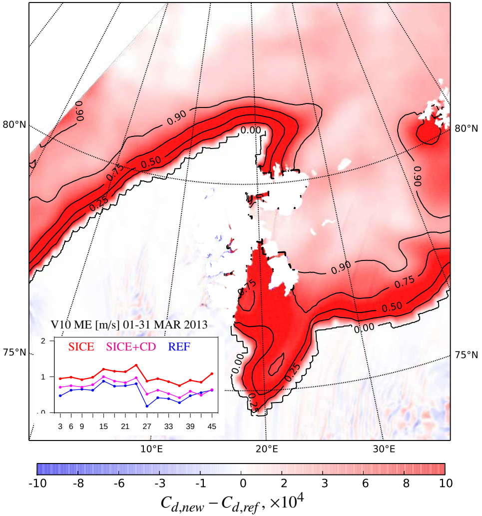


A – V_{10m} mean error, 7 Svalbard stations
B – floating ice as seen by SURFEX
C – floating ice in real life

- Positive bias of 10m wind speed when SICE is enabled
  - Caused by introduction of the ice fraction field
  - Grid cells with $SIC < 1$ contain some amount of open water
  - As result average *Cd* from such grid cell is decreased
- Ice fraction handling utilizes standard SURFEX approach for averaging
  - $F_{SEA} = (1-\alpha)F_{\text{water}} + \alpha F_{\text{ice}}$

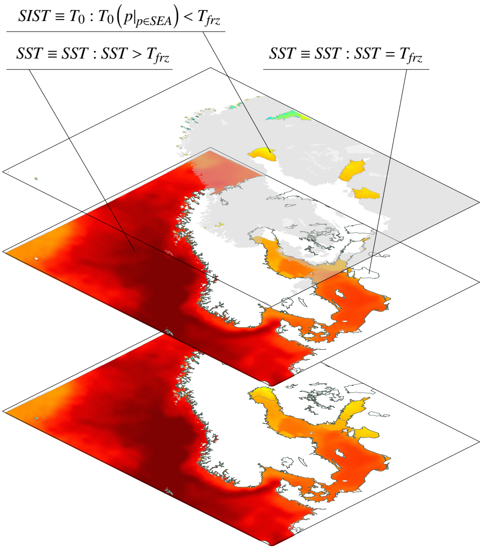
10 meter wind speed over ice surface

10 MAR 2013 00:00Z



- Introduce additional drag caused by ice obstacles
  - $C_{dn} = (1-\alpha)\,C_{d,w} + \alpha \cdot C_{d,i} + C_{d,f}$
  - $C_{df} = A\,(1-\alpha)^B\,\alpha$

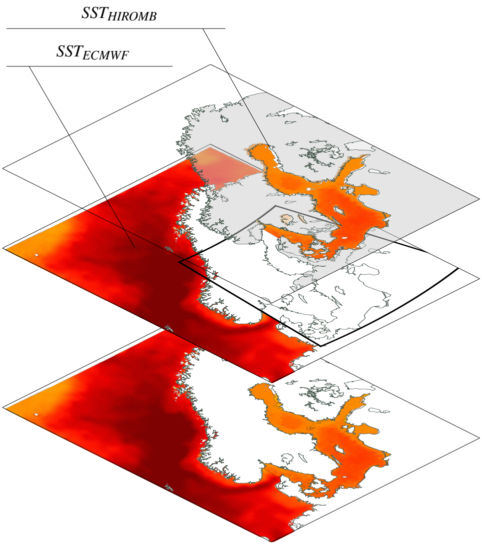
AROME experiments



Preparation of the SST field in the reference version of Harmonie

- Experiments have been ran over MetCoOp and Arctic domains
- Default setup uses SST/SIST from ECMWF

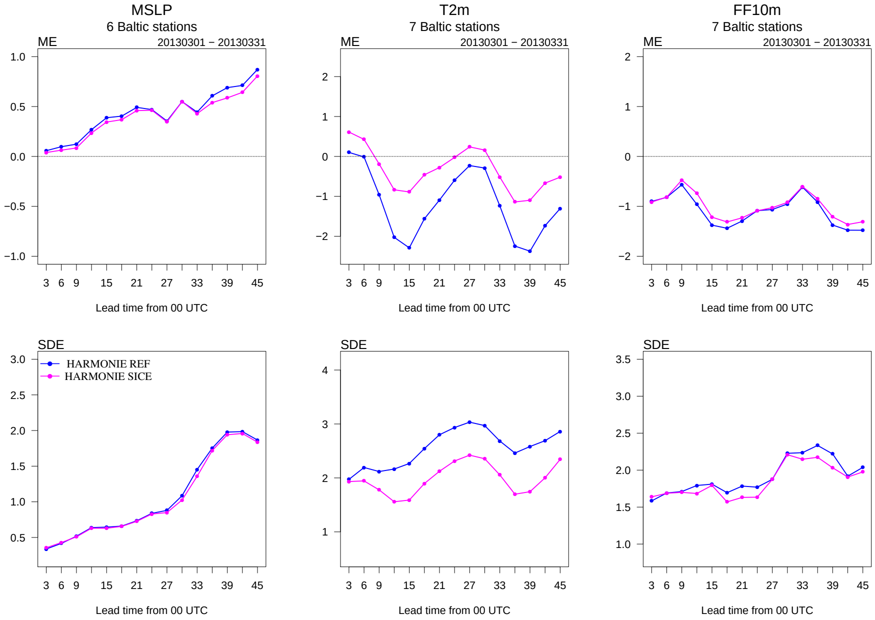
AROME experiments



- SICE setup
    - snow-free configuration
    - 4 layers of ice
    - ice thickness 0.5m
    - SIC from HIROMB data
- cycle initialization
    - SIST from the previous forecast
    - new ice is initialized by simple extrapolation from the border of the existing ice
    - linear temperature profile for the new ice

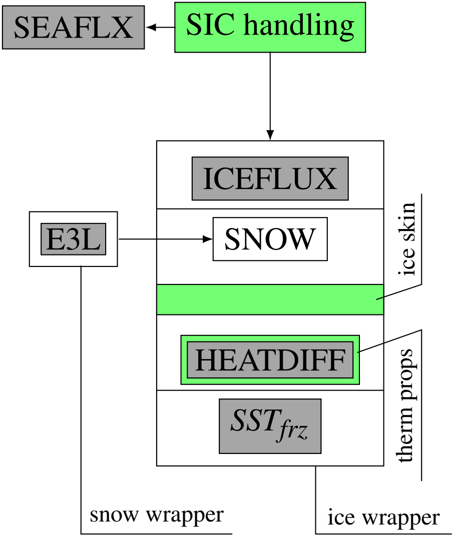
When SICE is enabled, *SST* field contains only water temperature

AROME experiments



Thank you for your attention!

A1: SICE structure



- Maximal usage of the existing code
- Data should be stored locally without spreading on different modules

SICE it's a combination of the already existing routines

A2: Implementation

- Fortran 2003
- Abstract interface for an ice scheme with two realizations
  - Default ICEFLUX scheme
  - SICE
- Data are stored locally in the corresponding derived types
- Unified descriptor-based IO processing for all ice-related fields

A3: Why the OO solution

```fortran
select case(CSCHEME)
  case('SCHEME_A')
    ! Scheme call...
  case('SCHEME_B')
    ! Scheme call...
end select
```

```fortran
call scheme%run(...)
```

```
  call    _gfortran_select_string
  testl   %eax, %eax
  je      .L3
  cmpl    $1, %eax
  je      .L4
  /*...*/
.L3
/*...*/
  call scheme_a_
  /*...*/
```

```
movq     -488(%rbp), %rax
movq     8(%rax), %rax
movq     40(%rax), %rax
call     *%rax
```

- Shorter code, clear structure
- Eliminated call to the Fortran runtime

Questions?