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

**T2M (7 Baltic stations)**
20130301–20130331

**ME [°C]**

**Lead time from 00 UTC**
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
N ice layers: \[T_i\]

Water: \[T = T_{frz}\]

- 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
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

- 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
  - $F_{SEA} = (1 - \alpha)F_{water} + \alpha F_{ice}$

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

- 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

\[
\begin{align*}
SIST & \equiv T_0 : T_0 \left( p | p \in \text{SEA} \right) < T_{frz} \\
SST & \equiv SST : SST > T_{frz} \\
SST & \equiv SST : SST = T_{frz}
\end{align*}
\]

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

Preparation of the SST field in the reference version of Harmonie
When SICE is enabled, SST field contains only water temperature

- **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
AROME experiments

MSLP
6 Baltic stations
20130301 – 20130331

T2m
7 Baltic stations
20130301 – 20130331

FF10m
7 Baltic stations
20130301 – 20130331

SDE
3 6 9 15 21 27 33 39 45

3 6 9 15 21 27 33 39 45

Lead time from 00 UTC

HARMONIE REF
HARMONIE SICE

Lead time from 00 UTC

Lead time from 00 UTC

Lead time from 00 UTC
Thank you for your attention!
SICE it’s a combination of the already existing routines

- Maximal usage of the existing code
- Data should be stored locally without spreading on different modules
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 (CSCHME)
  case ('SCHEME_A')
    ! Scheme call...
  case ('SCHEME_B')
    ! Scheme call...
end select

call scheme%run(...)  

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?