Challenges in validating model results for first year ice

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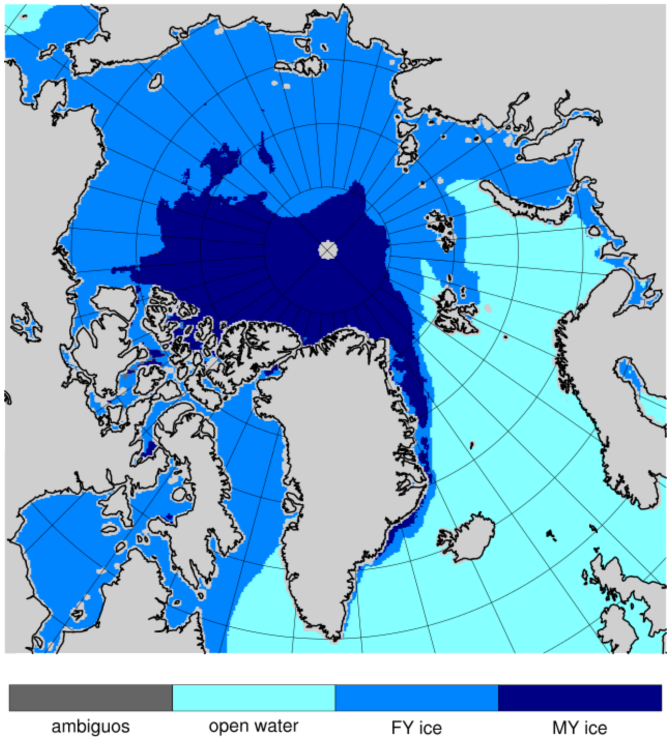
Average conditions, February 2016

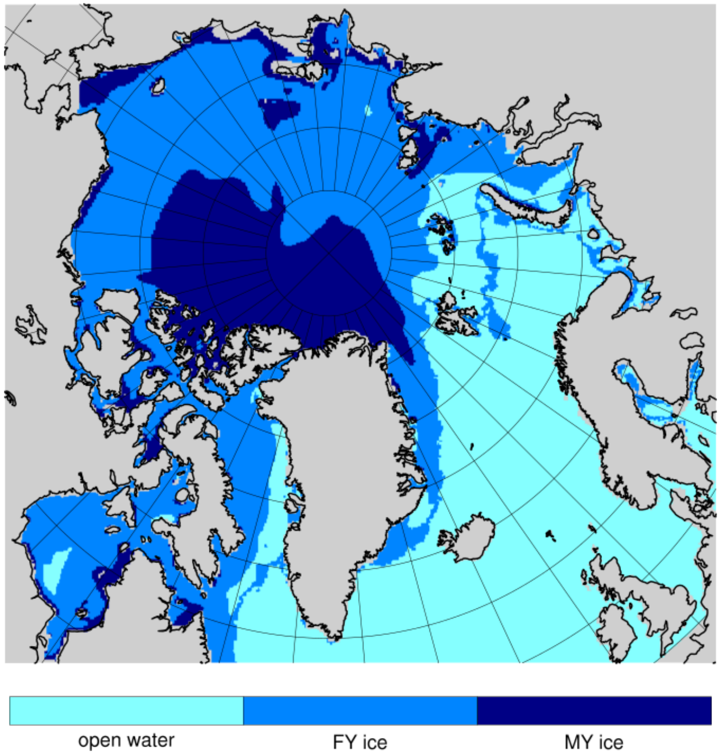
Observational product from EUMETSAT OSI SAF

(Ocean and Sea Ice Satellite Application Facility)



Model product from CMEMS ARC MFC

(Arctic Monitoring and Forecasting Centre)



Sea ice products from CMEMS

- GLOBAL_ANALYSIS_FORECAST_PHY_001_024
- GLOBAL_ANALYSIS_FORECAST_PHYS_001_015
- GLOBAL_REANALYSIS_PHY_001_025
- GLOBAL_REANALYSIS_PHYS_001_011
- GLOBAL_REANALYSIS_PHYS_001_017
- **ARCTIC_ANALYSIS_FORECAST_PHYS_002_001_a** FY, MY ice info.
- ARCTIC_REANALYSIS_PHYS_002_003
- BALTICSEA_ANALYSIS_FORECAST_PHYS_003_006
- BALTICSEA_REANALYSIS_PHYS_003_008
- SST_GLO_SST_L4_NRT_OBSERVATIONS_010_014
- SST_GLO_SST_L4_NRT_OBSERVATIONS_010_001
- SST_GLO_SST_L4_REP_OBSERVATIONS_010_011
- SST_EUR_SST_L4_NRT_OBSERVATIONS_010_018
- SST_BAL_SST_L4_REP_OBSERVATIONS_010_016
- **SEAICE_GLO_SEAICE_L4_NRT_OBSERVATIONS_011_001** FY, MY ice info.
- SEAICE_GLO_SEAICE_L4_NRT_OBSERVATIONS_011_006
- SEAICE_GLO_SEAICE_L4_REP_OBSERVATIONS_011_009
- SEAICE_ARC_SEAICE_L4_NRT_OBSERVATIONS_011_008
- SEAICE_ARC_SEAICE_L4_NRT_OBSERVATIONS_011_003
- SEAICE_ARC_SEAICE_L4_NRT_OBSERVATIONS_011_002
- SEAICE_ARC_SEAICE_L3_REP_OBSERVATIONS_011_010
- SEAICE_BAL_SEAICE_L4_NRT_OBSERVATIONS_011_004
- SEAICE_BAL_SEAICE_L4_NRT_OBSERVATIONS_011_011
- SEAICE_ANT_SEAICE_L4_NRT_OBSERVATIONS_011_012

Selected applications for FY ice, MY ice separation

- Presence of multi-year ice affects navigation and operations in the Arctic
- Contrasting properties (salinity, roughness) are used in interpretation of observations of sea ice thickness
- Interannual and decadal trends in multi-year ice are of high relevance for projecting the timing of ice-free conditions in the Arctic summer

Determination of ice type from *observations*

- SSMIS spectral gradient GR1937:

  The normalised difference in brightness temperature between 37 GHz and 19 GHz

  Primarily used since the gradient is affected by changes in emissivity due to brine rejection

  (Salt contents in sea ice decreases from brine rejection as age increases)

- ASCAT normalized backscatter

  Primarily used since the signal is affected by surface roughness and volume scattering

  (Roughness generally increases with ice age due to ridging)

Definition of multi-year ice in *observations*

Goal:

- To classify sea ice that has survived a summer season as multi-year ice

Sources of uncertainties and errors in *observations*

- Snow on first year ice
- Meltponds on first year ice
- Ridging of first year ice
- Combination of first year and multi-year ice in pixel
- Description of conditions in the atmosphere (humidity)

Definition of ice age in *model product*

- In each grid cell the model distinguishes between
  the total fraction of sea ice
  the fraction of first year ice
- When freezing, the age of the newly formed ice is initialized
- If the age becomes 1 year, the fraction of first year ice is set to 0
- Exception: Ridged ice is removed from first year ice category
- Age of first year ice is updated as a volume average based on advection, freezing and melting

Sources of uncertainties and errors in *model product*

- Thermodynamic forcing
  - ocean temperature profile
  - atmospheric profiles (temperature, humidity)
- Model dynamics
  - model ice age relies (cumulatively) on description of ice drift
- Sub-grid scale parameterizations
  - lead fraction
  - ridging

Compatible *observations* and *model product*

- Definition of transition from first year to multi-year ice

    observations: time of ice minimum

    model product: age exceeds 365 days

- Character of gridded products

    observations: binary

    model product: FY, MY ice in same grid

- Transition:

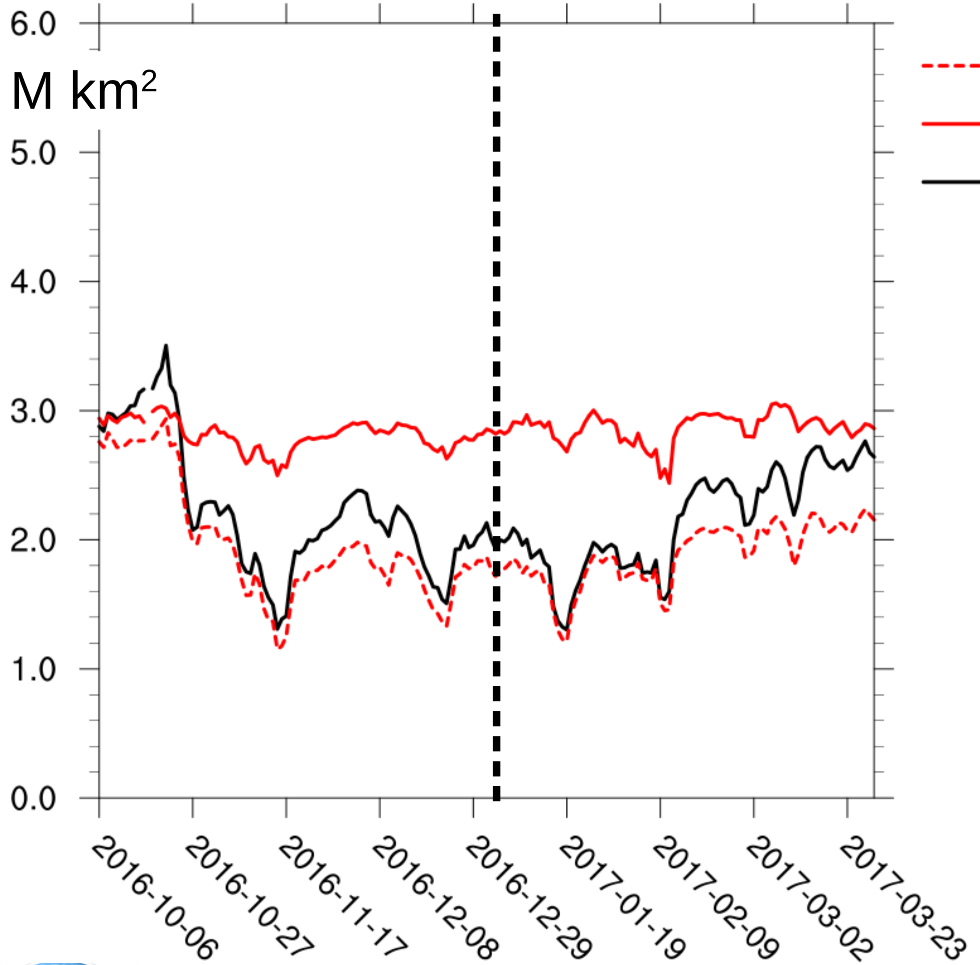
    Model first year ice & age > #days since minimum ⇒ model multi-year ice

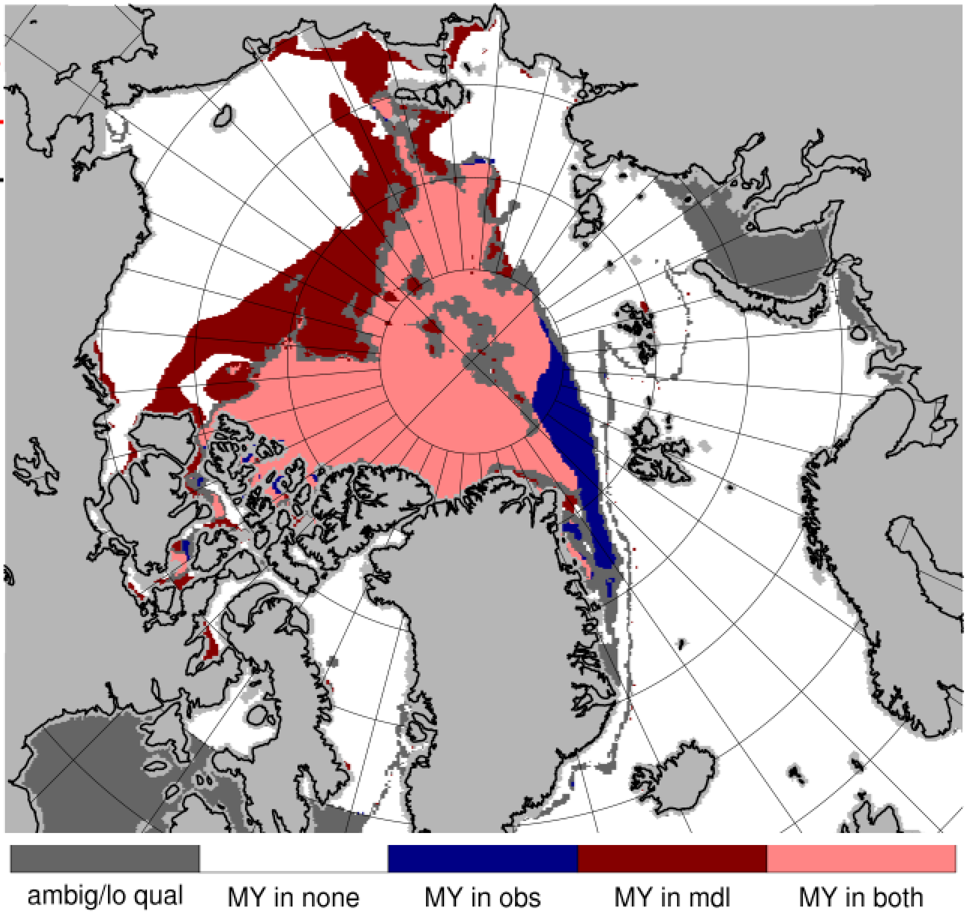
- Binary character:

    Model multi-year ice ≥ 0.5 ⇒ multi-year ice grid

    < 0.5 ⇒ first year ice grid

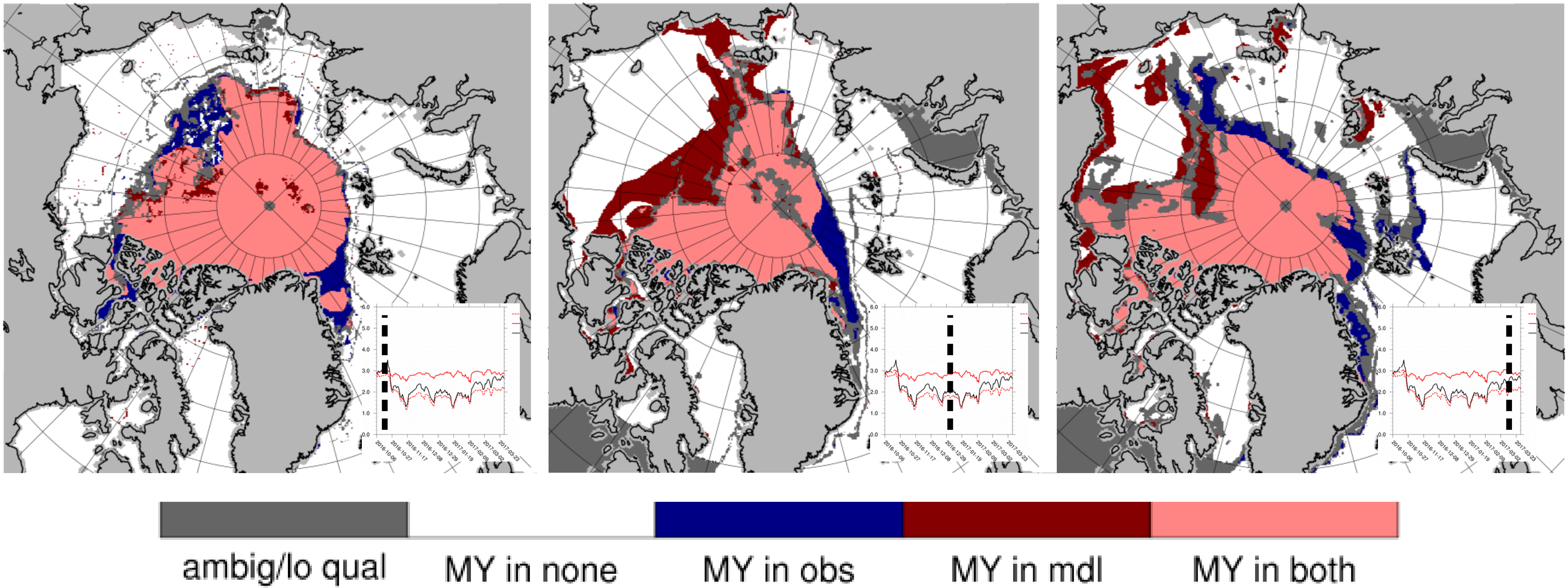
Extent of multi-year ice



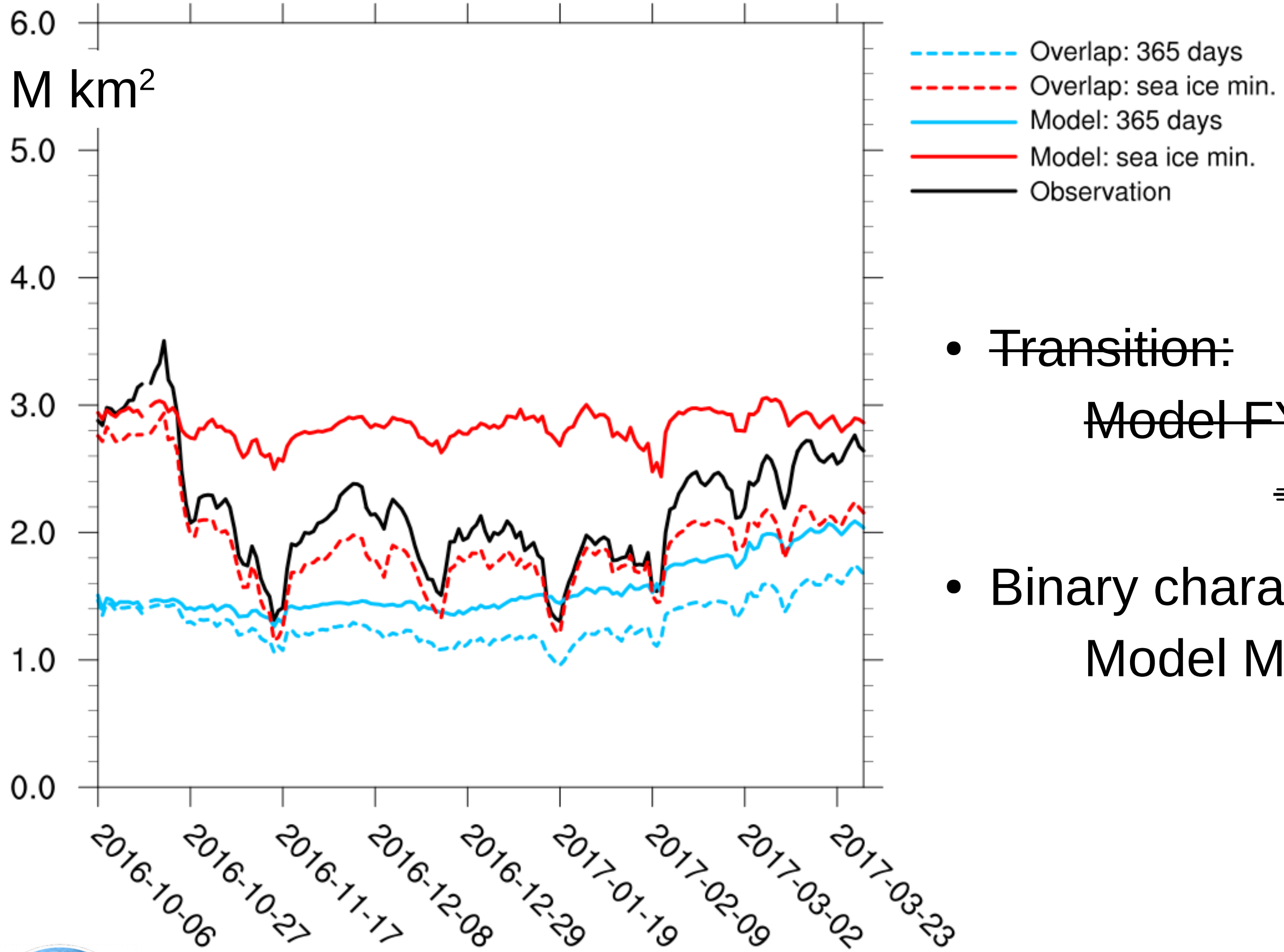


Extent of multi-year ice

2016-10-19 *2017-01-04* *2017-03-15*



Extent of multi-year ice: sensitivity to model transition date



- ~~Transition:~~

  ~~Model FY ice & age > #days since mnm~~

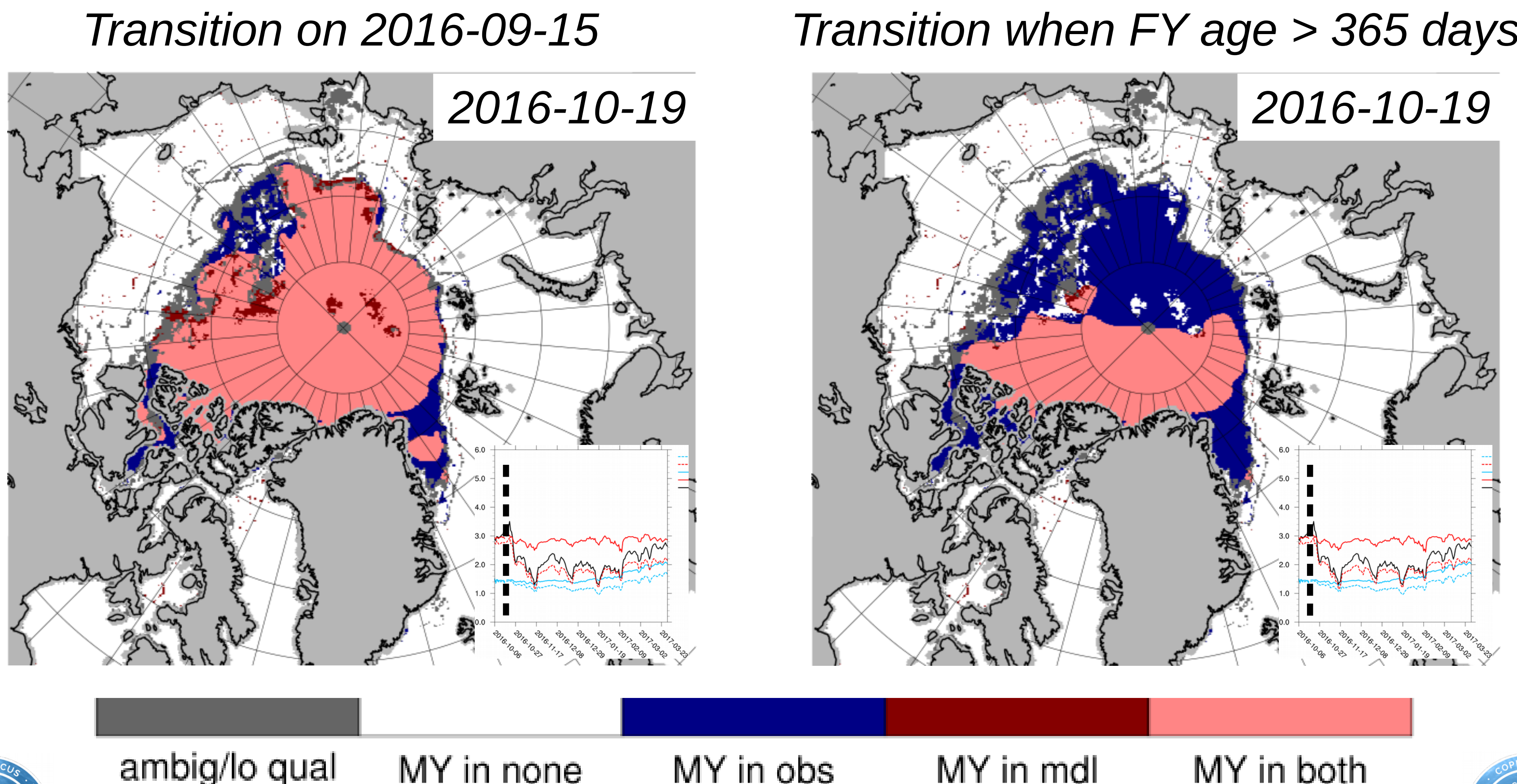
  ~~⇒ model multi-year ice~~

- Binary character:

  Model MY ice ≥ 0.5 ⇒ MY ice grid

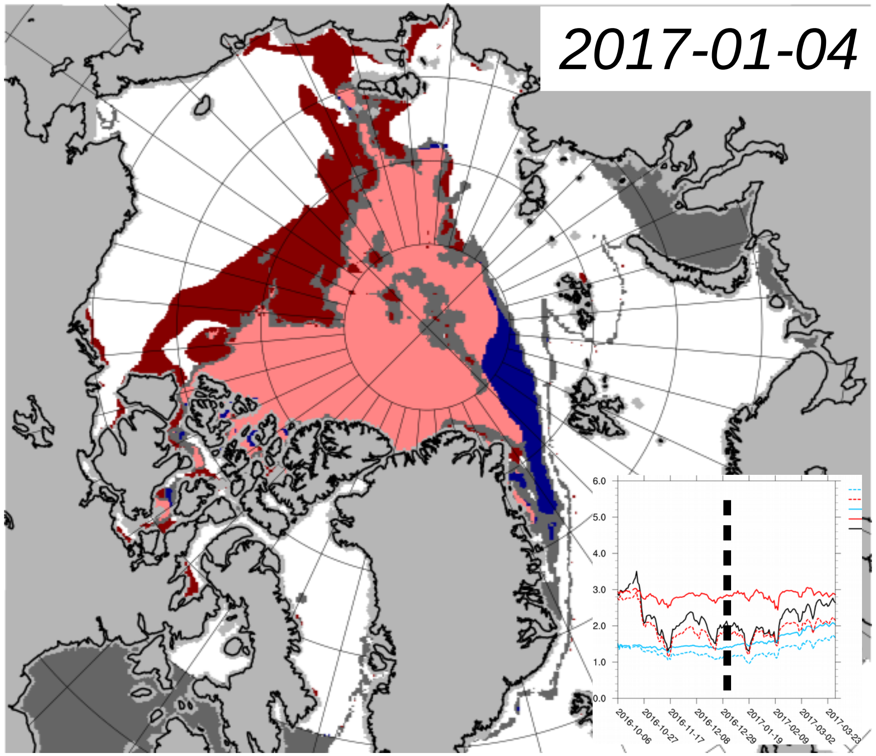
  < 0.5 ⇒ FY ice grid

Extent of multi-year ice: sensitivity to model transition date

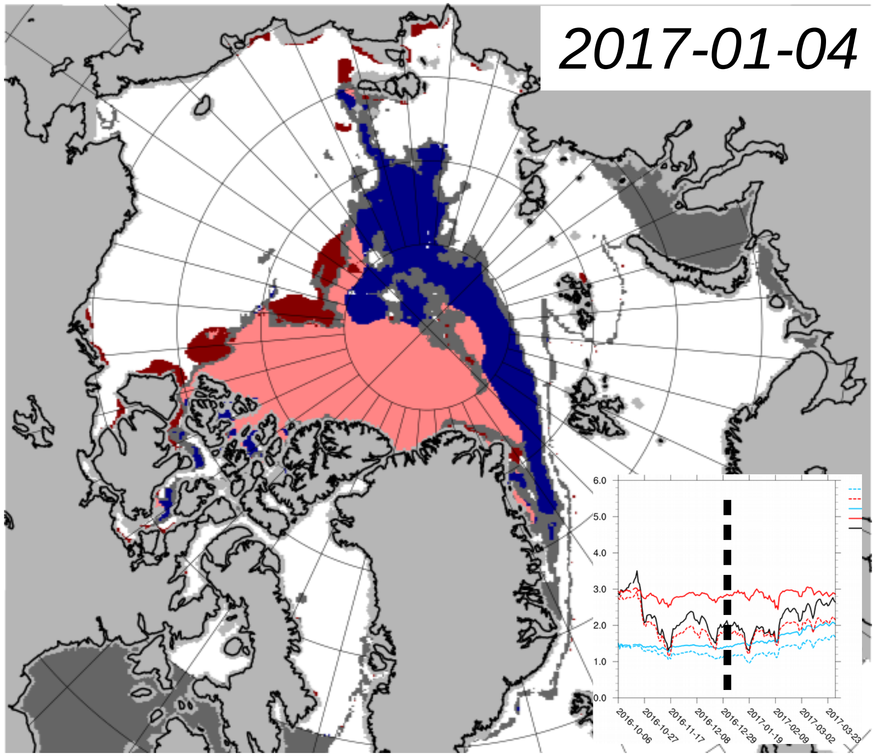


Extent of multi-year ice: sensitivity to model transition date

Transition on 2016-09-15



Transition when FY age > 365 days



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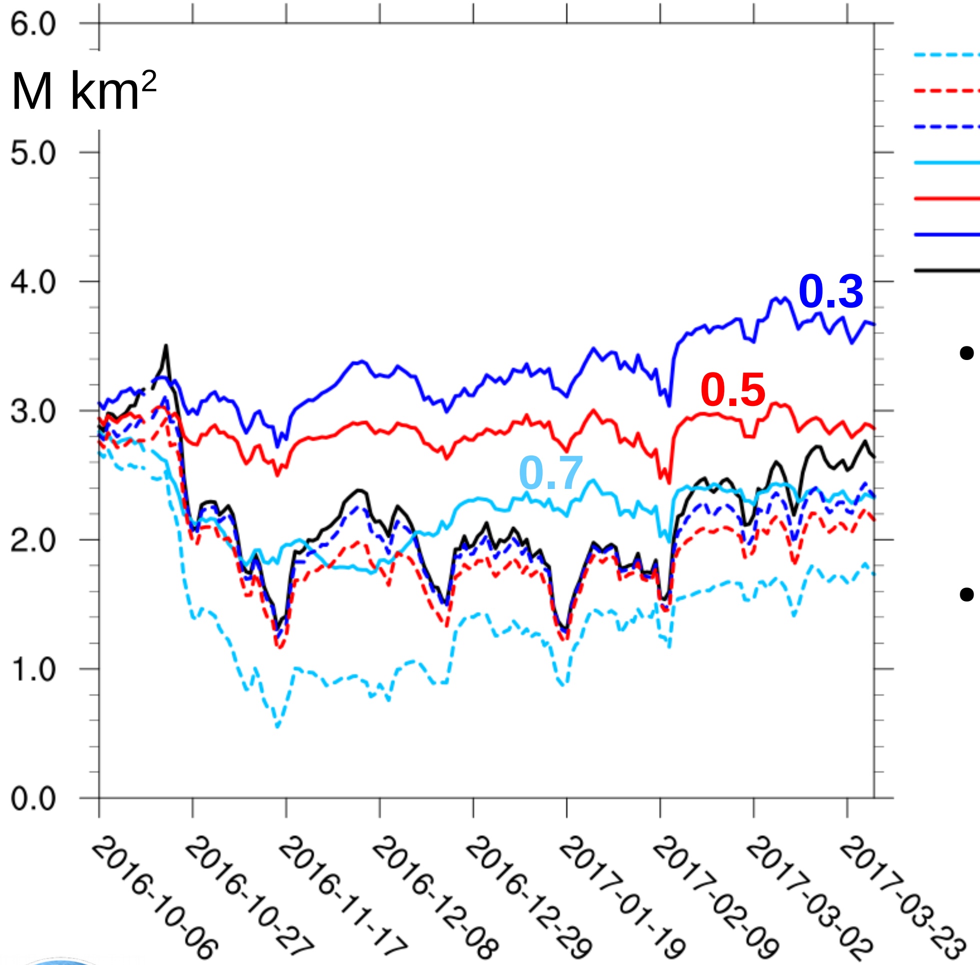
Extent of multi-year ice: sensitivity to MY limit



- Transition:

  Model FY ice & age > #days since mnm

  ⇒ model multi-year ice

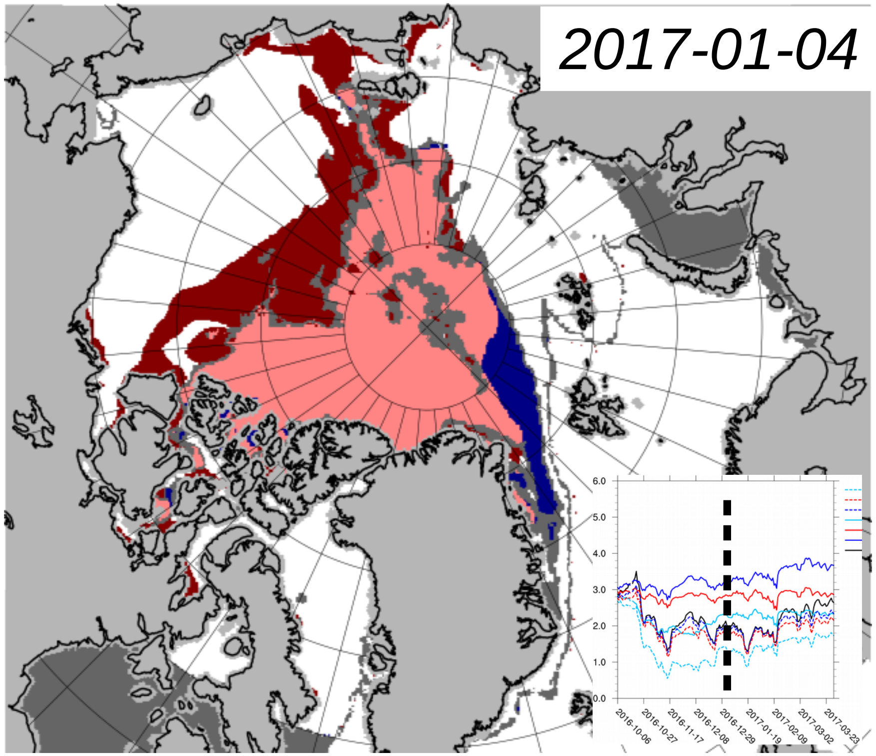
- Binary character:

  Model MY ice ≥ **X** ⇒ MY ice grid

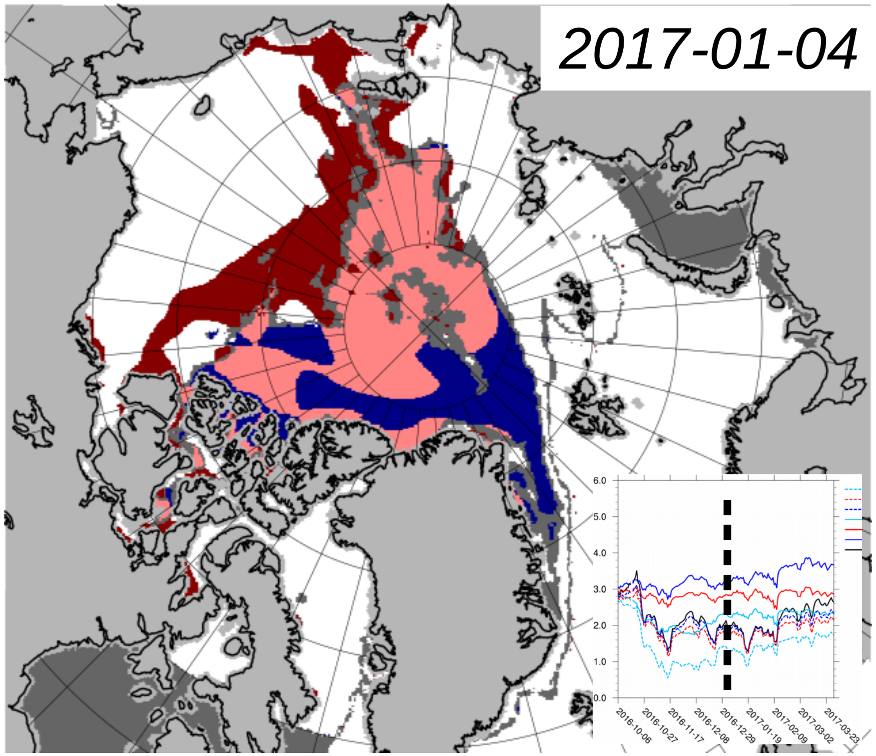
  < **X** ⇒ FY ice grid

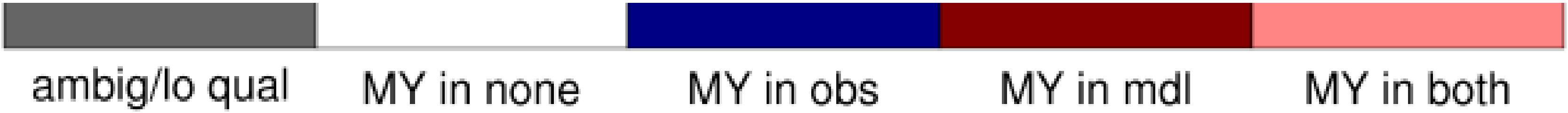
Extent of multi-year ice: sensitivity to MY limit

MY model concentration limit: ***0.5***



MY model concentration limit: ***0.7***





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Summary

- Observational product combines measurements from two sensors, increasing the sensitivity to accuracy of algorithms
- Model product is sensitive to accumulated displacements due to inaccuracies in representation of ice drift
  (in addition to effects of forcing, sub-grid parameterizations)

  ⇒ both products conceivably affected by shortcomings
- Variability in model results for multi-year ice extent from past six months is much lower than variability in observations
- When comparing products, results here
  - are inconclusive w.r.t. optimal model MY → FY transition date
  - indicate that a MY limit of 0.5 is OK for binary representation