Snow Mods

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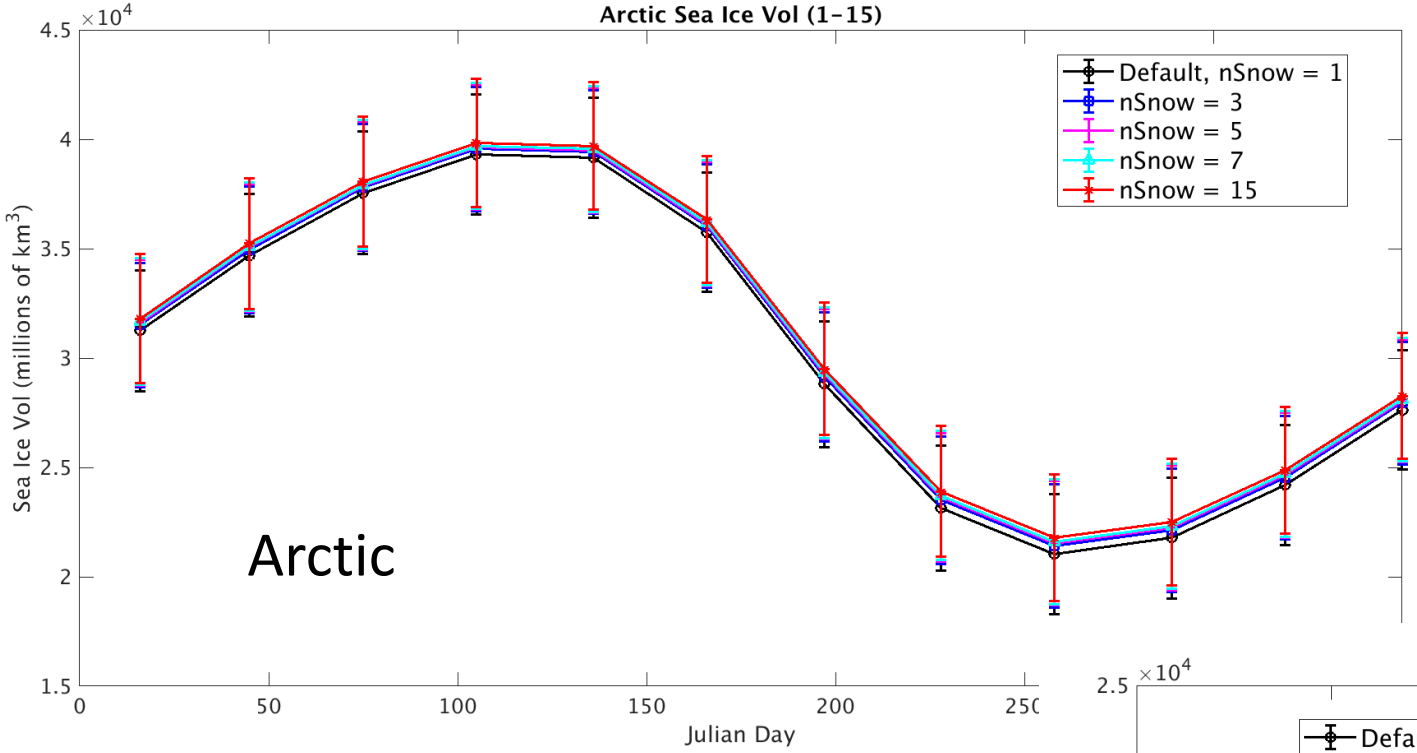
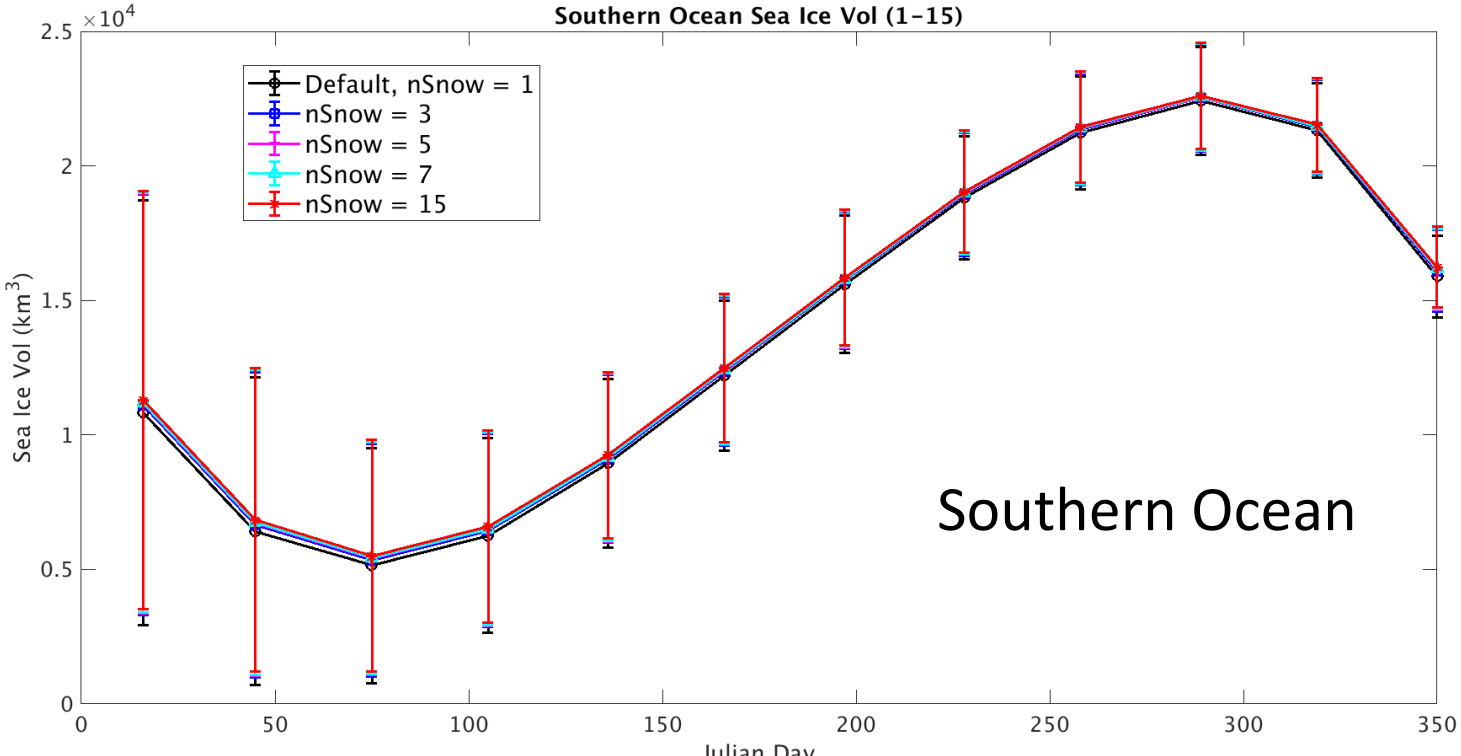
June 17, 2019

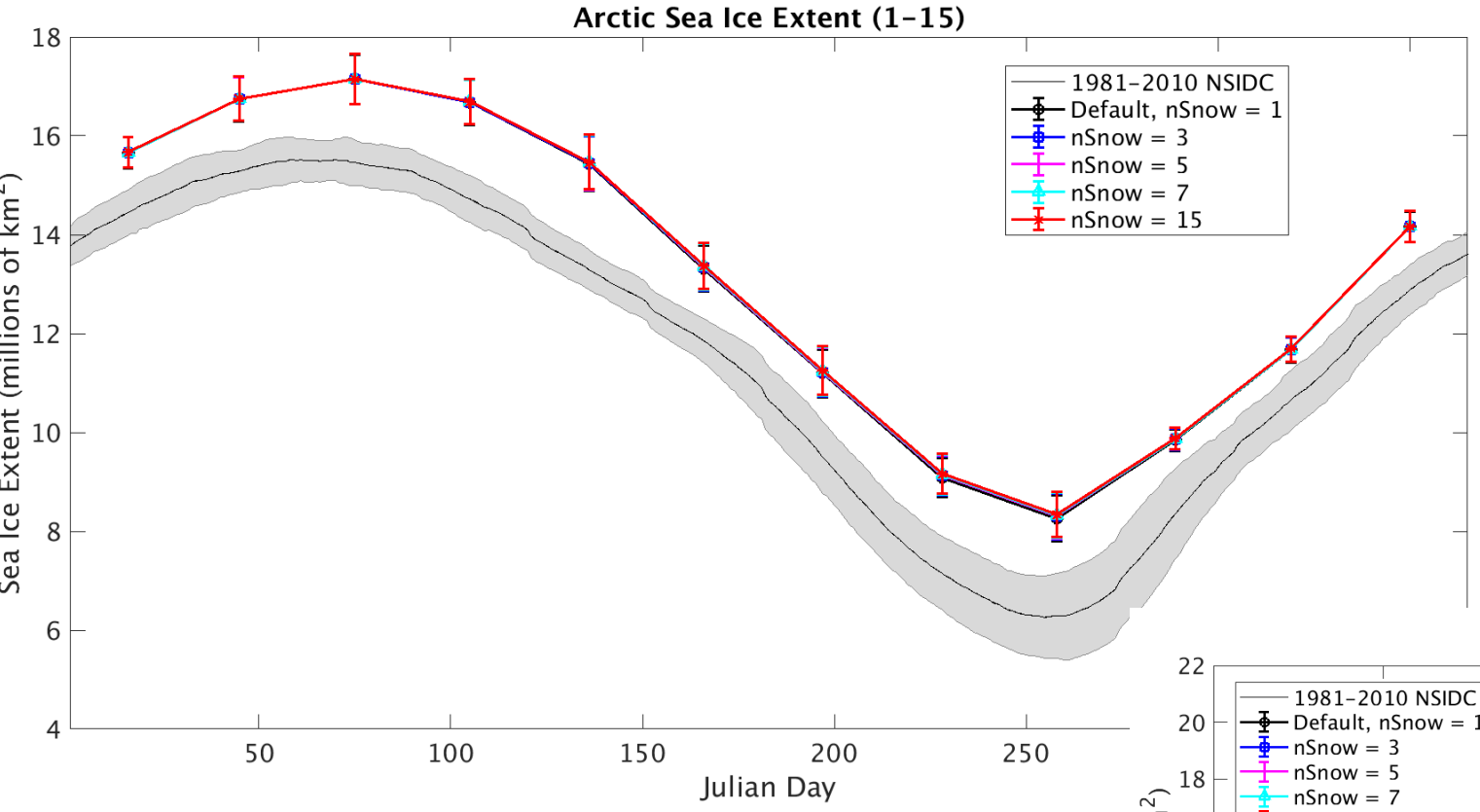


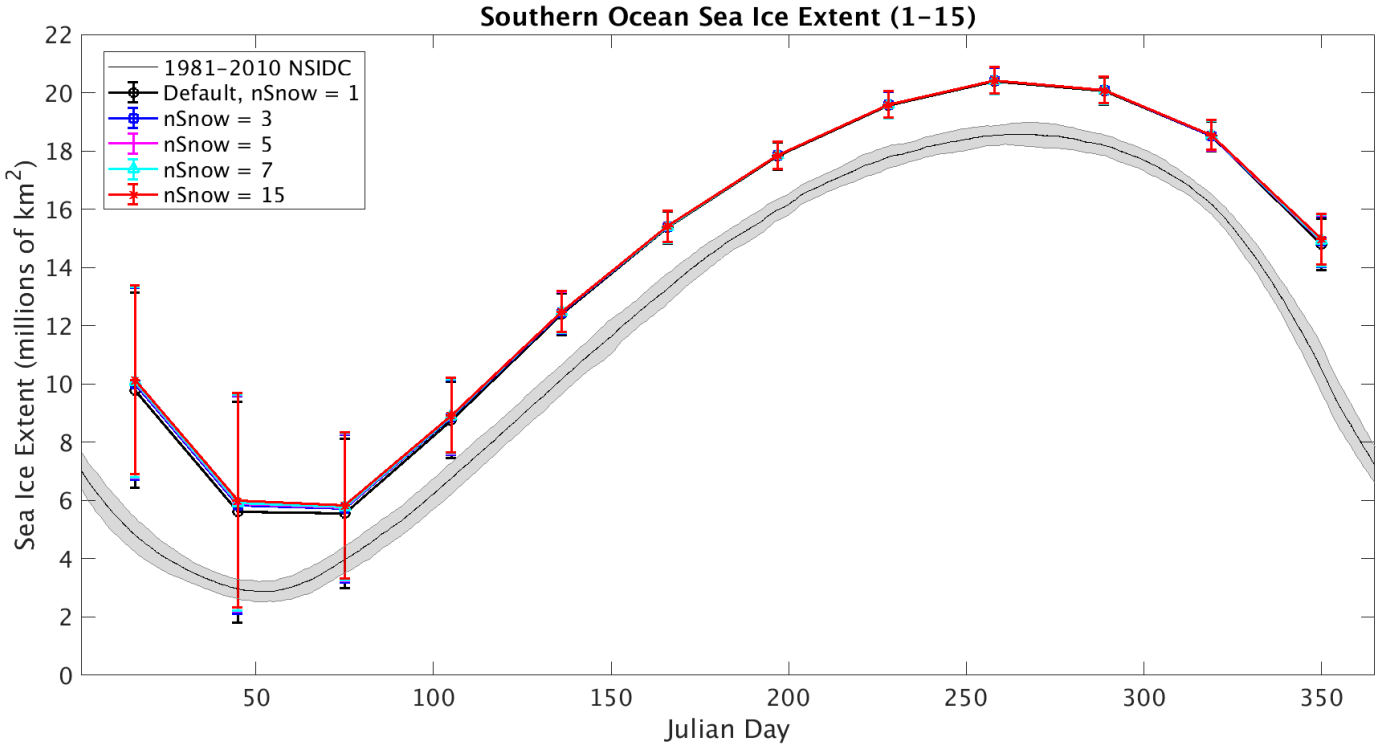
Changing the number of Snow Layers

Default is nSnow = 1

Sea Ice Volume (years 1-15 of JRA-55)

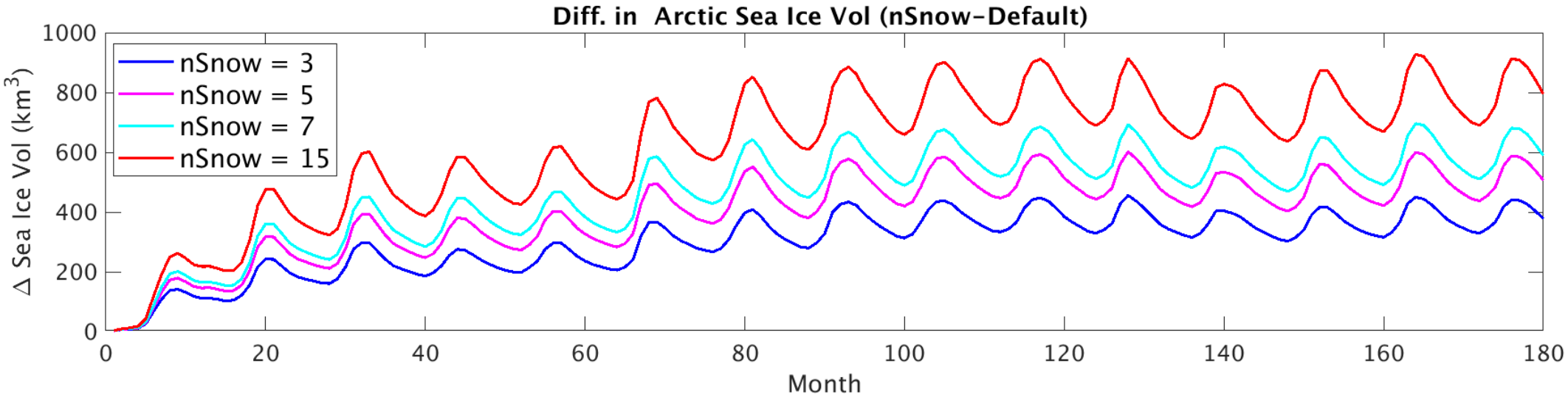


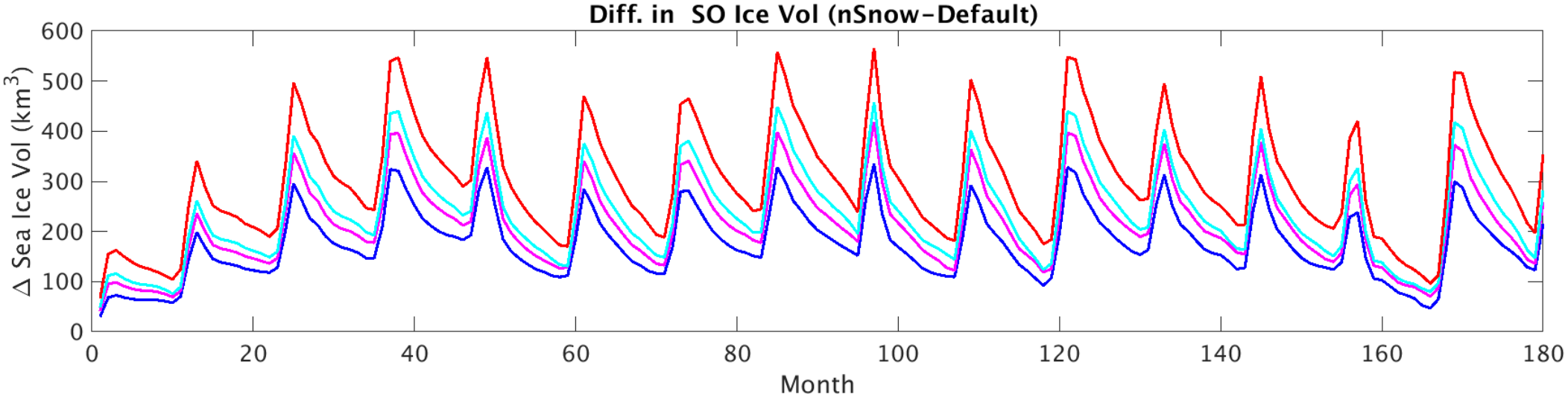




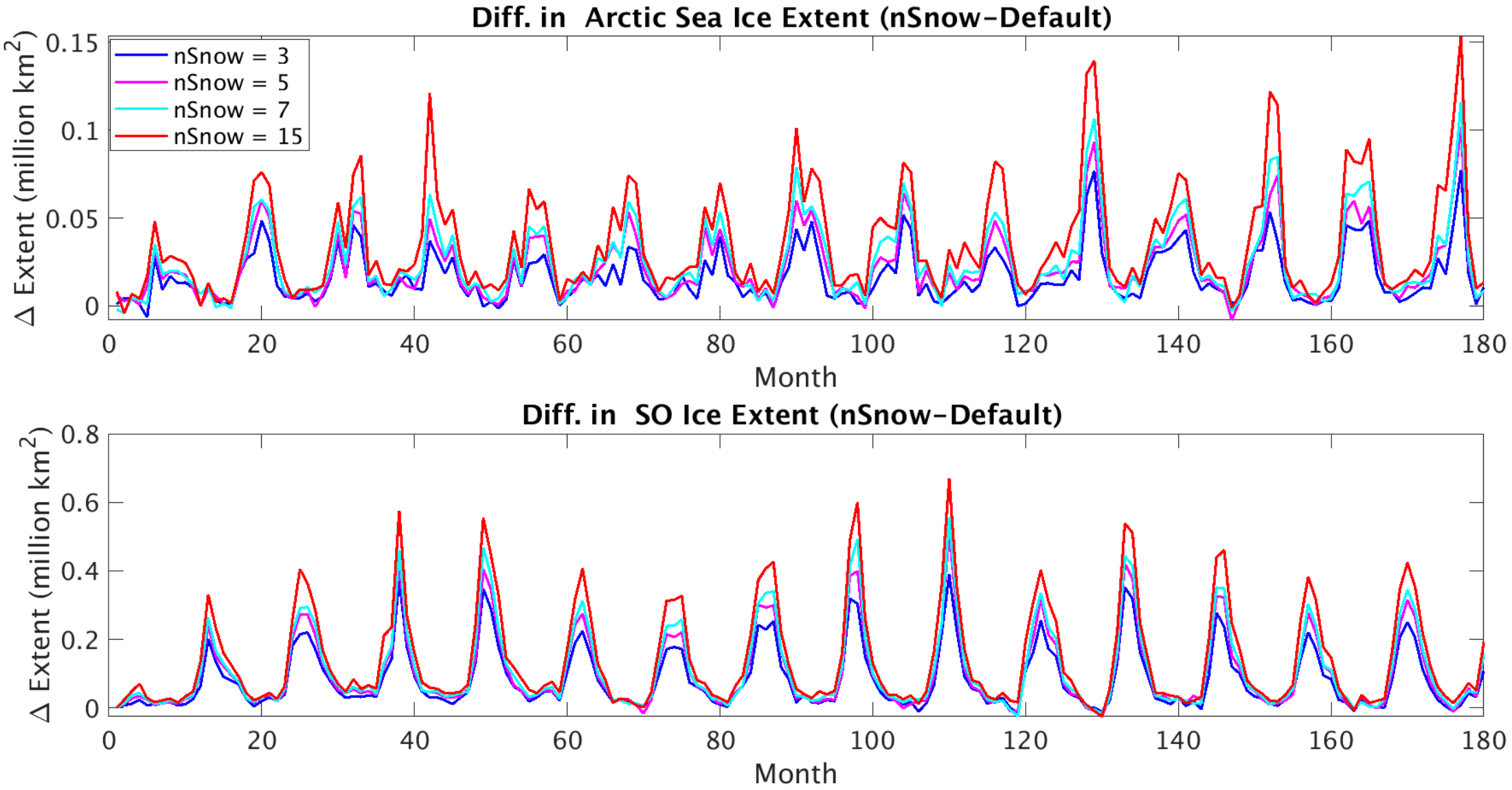
Sea Ice Extent
(years 1-15 of JRA-55)

Difference in Ice Volume (nSnowLayer-Default)





Difference in Sea Ice Extent (nSnowLayer-Default)



Possible Snow layer dependence of model

- Initialization of snow profiles
  - Default initializes T/q with constant value profiles
- Definition of the hs_ssl = Snow Surface Layer.
  - Default defines:
    - rnslyr = 1/nslyr
    - dz = hs*rnslyr. ==> snow layer thickness
    - For small enough snow thicknesses, hs_ssl is half of top snow layer
    - *ech: Tech note* this is highly resolution dependent
      - dzk(0) = min(hs_ssl,dz/c2). Where hs_ssl = 0.040_dbl_kind

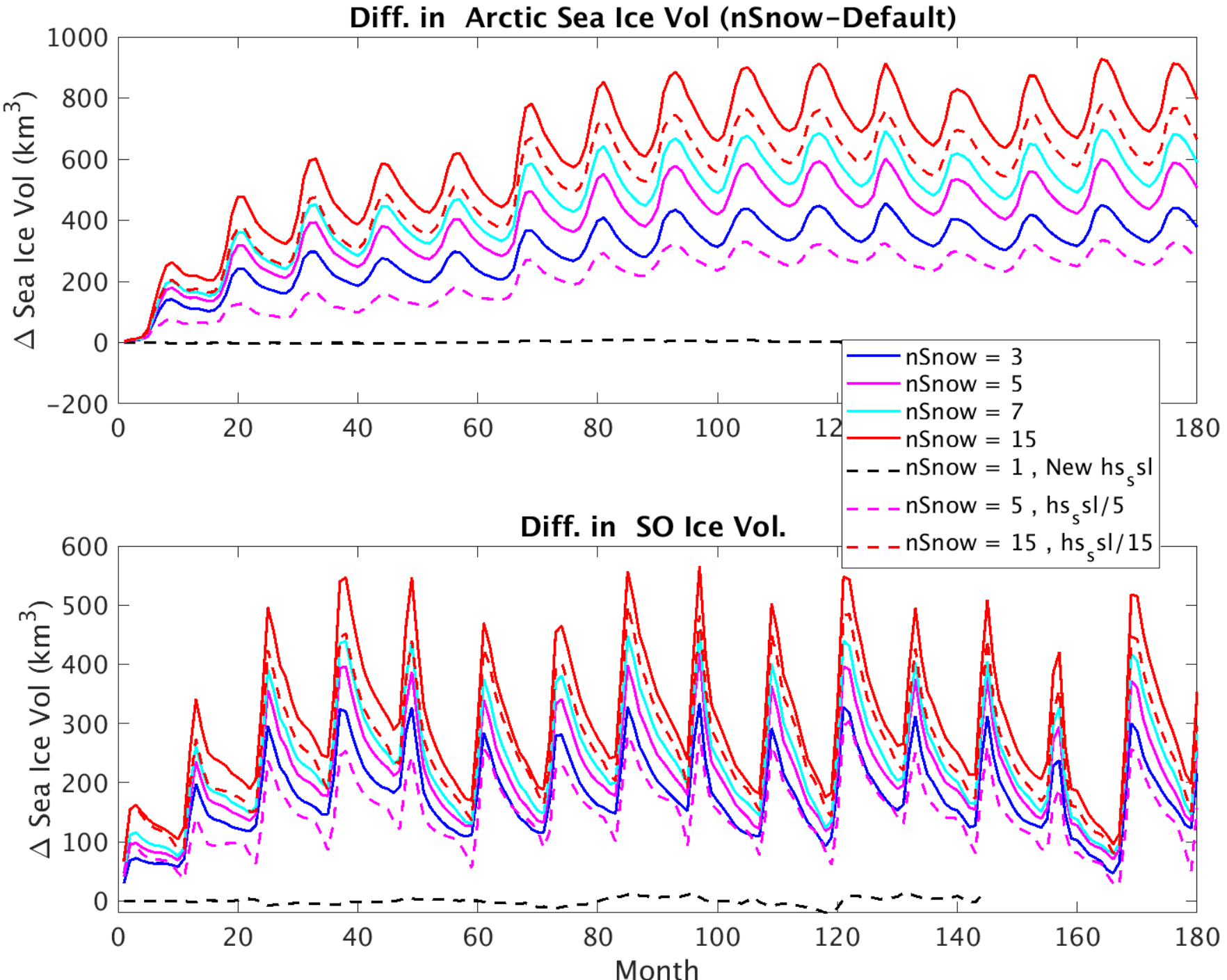
Is hs_ssl = 0.04 m a physical quantity? Sort of. It is length scale for how quickly radiation penetrates in 1 hour. Thus hs_ssl can be tuned, though it is hard coded. How does changing hs_ssl effect the model?

I've tested hs_ssl = 0.04/nslyr so that we use the same fraction of the top layer and start changing hs_ssl with snow layer thickness for the same minimum snow thickness as the 1 snow layer simulation.

More about the SSL (Surface Scattering layer)

- For snow, this is granular and porous, the refractive index is 1 (like air) and so there is no refraction
- For ice, the ssl is also granular an porous. However, below this layer ice has a refractive index of 1.31 and so refraction does occur (this additional layer in the ice is the Fresnel layer)

    - *Radiation absorbed in the snow ssl is used for surface heating, while that absorbed in the remaining snow layers is for internal heating.
- 0.04 m comes because for snow thermal conductivity, density, and heat capacity identical to sea ice, the thermal penetration depth for one hour flux exchange is 0.04 m …
- What is the impact of hs_ssl = 0.04/nslyr? For more layers, have a smaller ssl so that the ssl is fixed for the same snow thickness regardless of the number of layers.


Diff. in Arctic Sea Ice Vol (nSnow−Default)
Δ Sea Ice Vol (km3)
1000
800
600
400
200
0
−200
0
20
40
60
80
100
120
180
nSnow = 3
nSnow = 5
nSnow = 7
nSnow = 15
nSnow = 1 , New hssl
nSnow = 5 , hssl/5
nSnow = 15 , hssl/15
Diff. in SO Ice Vol.
Δ Sea Ice Vol (km3)
600
500
400
300
200
100
0
0
20
40
60
80
100
120
140
160
180
Month

Snow Modifications

- Effective snow grain radius (Rsnw): Default Scheme…
  - Delta-Eddington has optical parameters for the range ~5 to 2500 um
  - In the default scheme, Rsnw ranges (clear sky) from 125-1500 um with a tunable (R_snw = 1.5) linear increase with surface temperature (Tsfc).

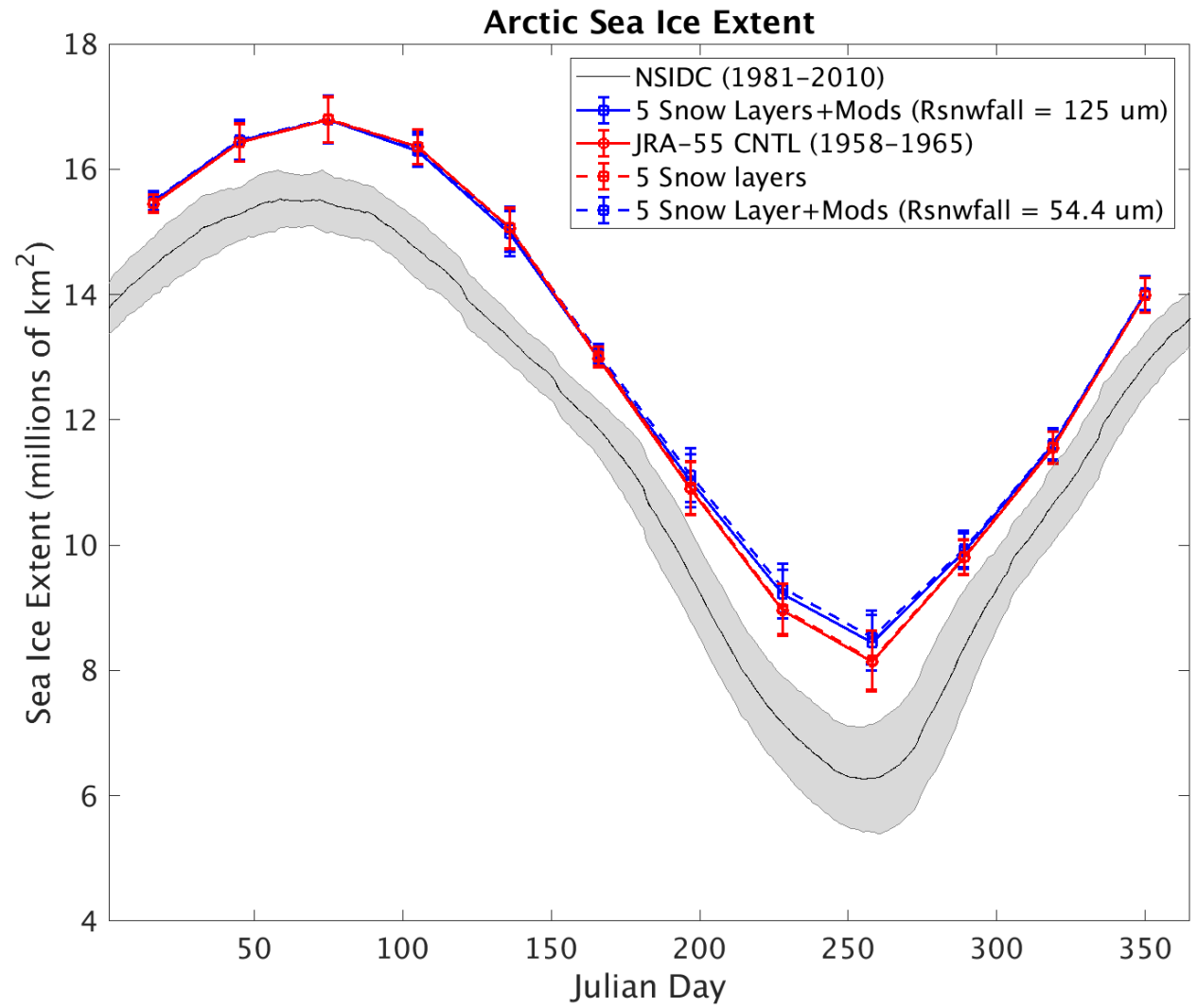
  - When Tsfc <= -1.5oC, Rsnw = 125 um
  - When Tsfc >= 0oC, Rsnw = 1500 um
  - When -1.5oC < Tsf < 0oC there's a linear increase in Rsnw.

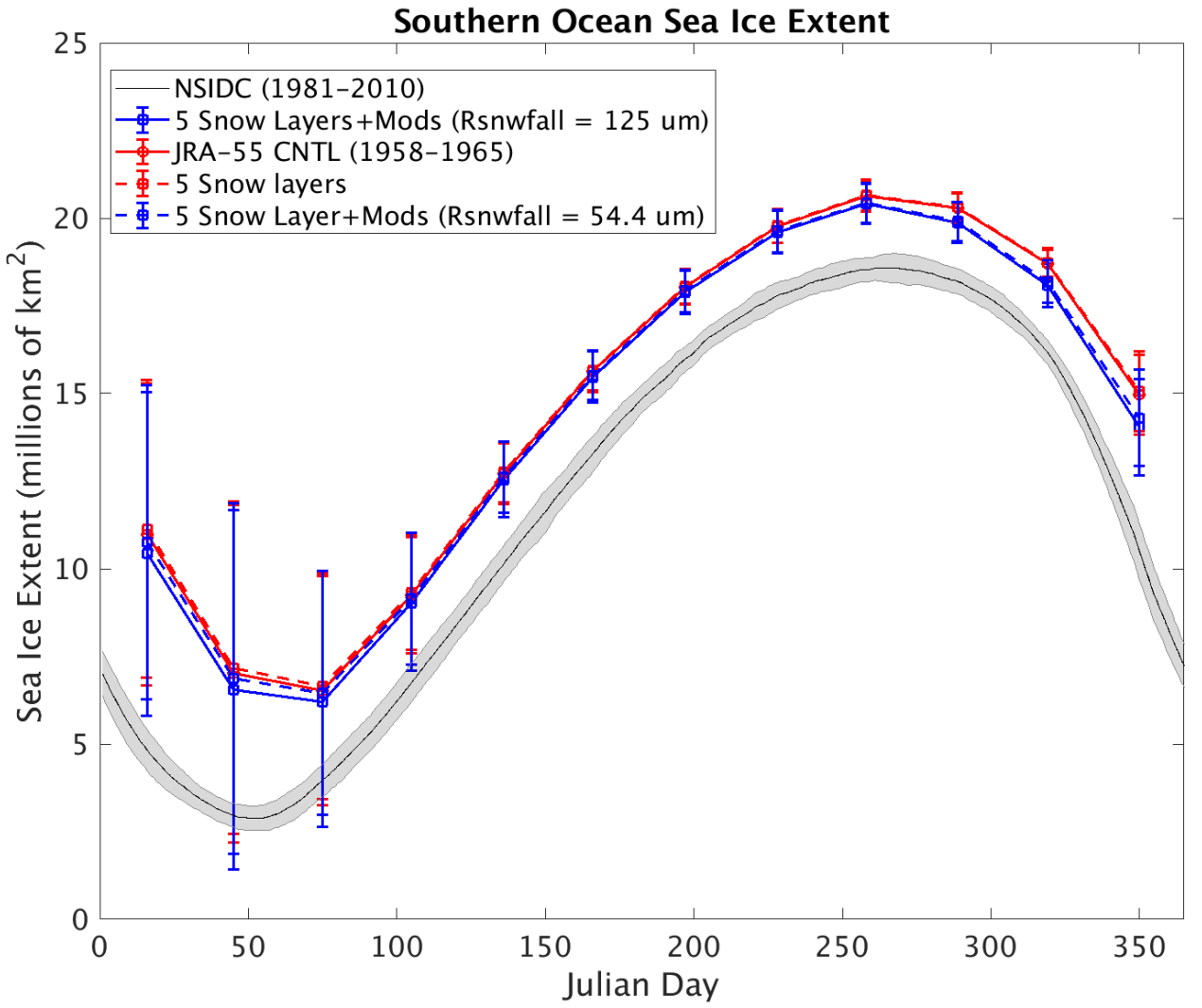
  Cloudy sky, reduce by at most 0.8*Rsnw

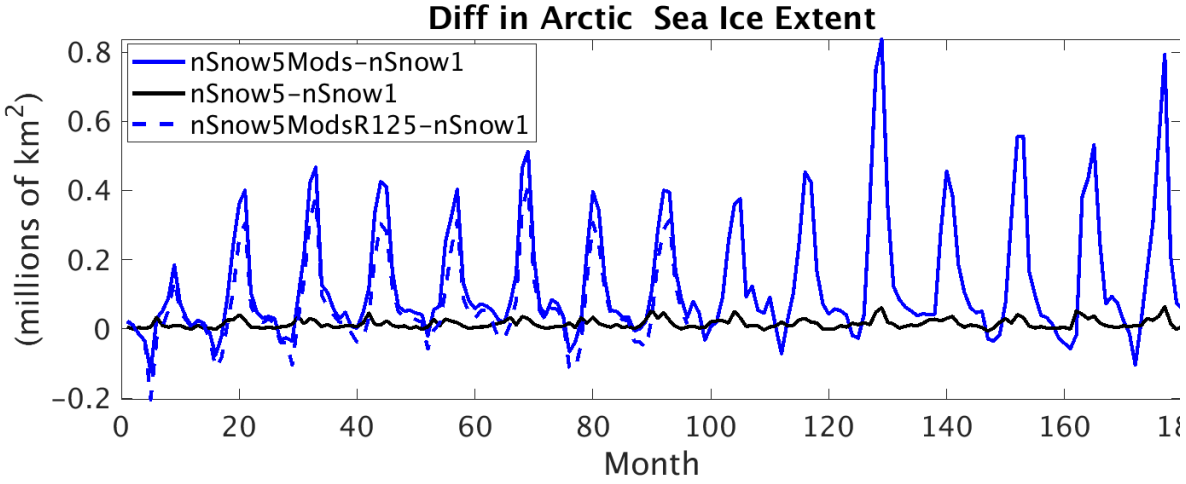
Snow Modifications

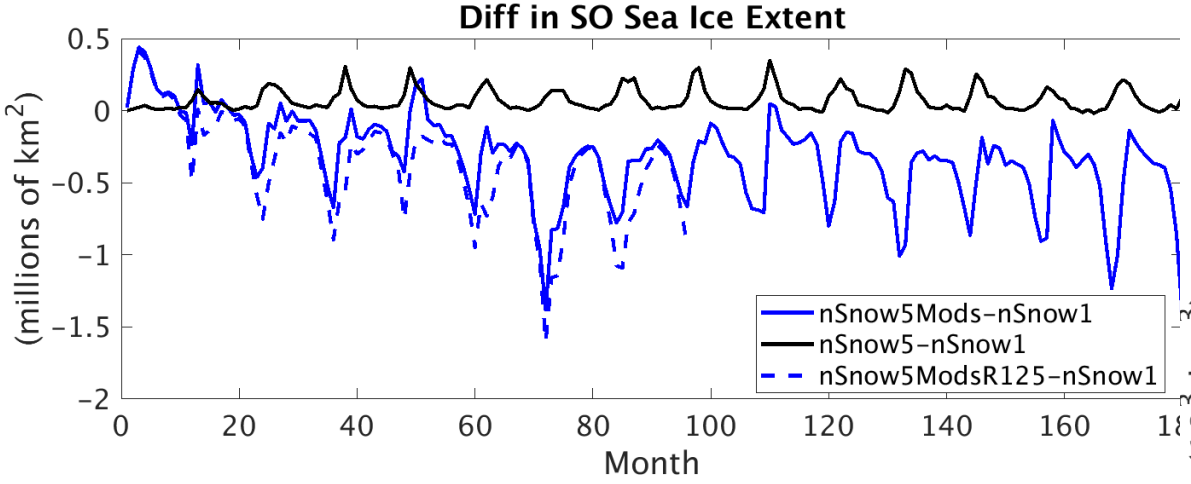
- Dynamic Effective snow grain radius (Rsnw):
  - Define effective radius of fresh snow: Test Rsnw_fall = 54.4 um and 125 um
  - Snow ages and Rsnw increases with
    - Gradients in temperature (scheme used in clm)
    - Liquid water content (rate of volume growth increases with % liquid content up to 10%). (one parameter from experiment)

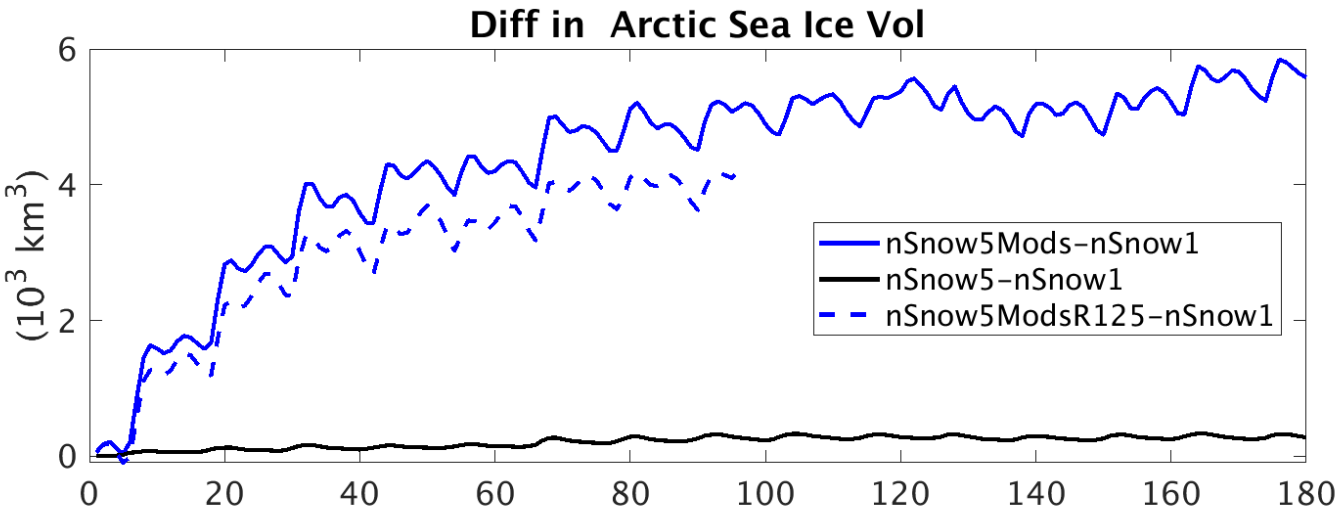
  Set maximum Rsnw_tmax = 2800 um.

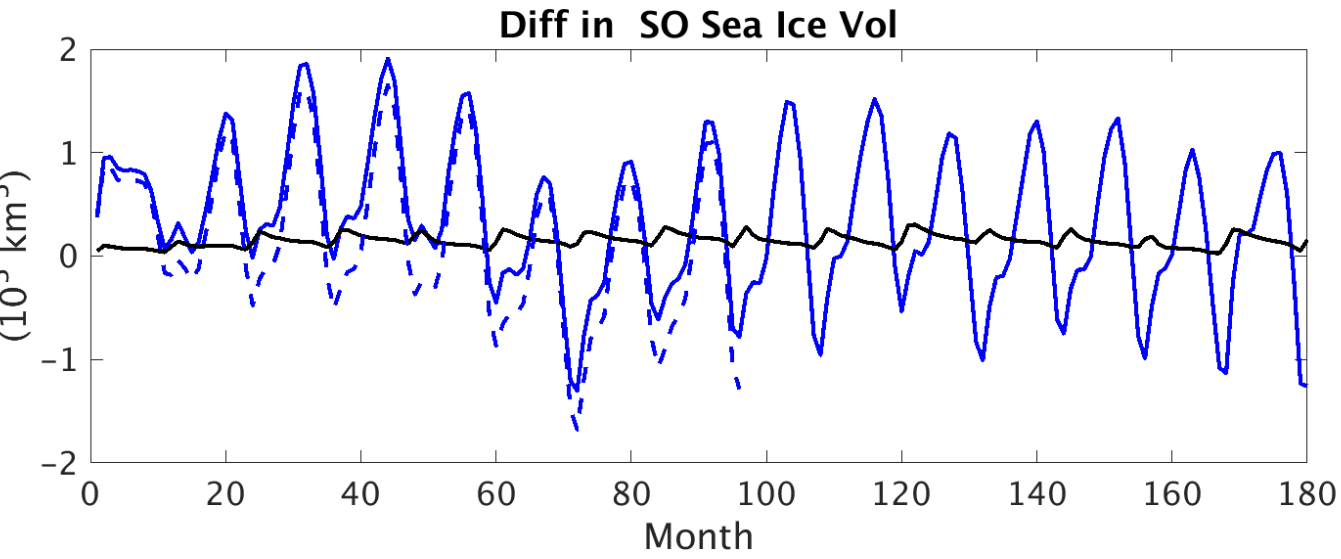

Arctic Sea Ice Extent
NSIDC (1981–2010)
5 Snow Layers+Mods (Rsnwfall = 125 um)
JRA–55 CNTL (1958–1965)
5 Snow layers
5 Snow Layer+Mods (Rsnwfall = 54.4 um)
Sea Ice Extent (millions of km2)
Julian Day
18
16
14
12
10
8
6
4
50
100
150
200
250
300
350


Southern Ocean Sea Ice Extent
NSIDC (1981–2010)
5 Snow Layers+Mods (Rsnwfall = 125 um)
JRA–55 CNTL (1958–1965)
5 Snow layers
5 Snow Layer+Mods (Rsnwfall = 54.4 um)
Sea Ice Extent (millions of km2)
Julian Day
25
20
15
10
5
0
0
50
100
150
200
250
300
350


Diff in Arctic Sea Ice Extent
nSnow5Mods-nSnow1
nSnow5-nSnow1
nSnow5ModsR125-nSnow1
(millions of km^2)
Month


Diff in SO Sea Ice Extent
nSnow5Mods-nSnow1
nSnow5-nSnow1
nSnow5ModsR125-nSnow1
(millions of km^2)
Month


Diff in Arctic Sea Ice Vol
nSnow5Mods-nSnow1
nSnow5-nSnow1
nSnow5ModsR125-nSnow1
(10^3 km^3)


Diff in SO Sea Ice Vol
(10^3 km^3)
Month