CLIMATE, OCEAN AND SEA ICE MODELING PROGRAM

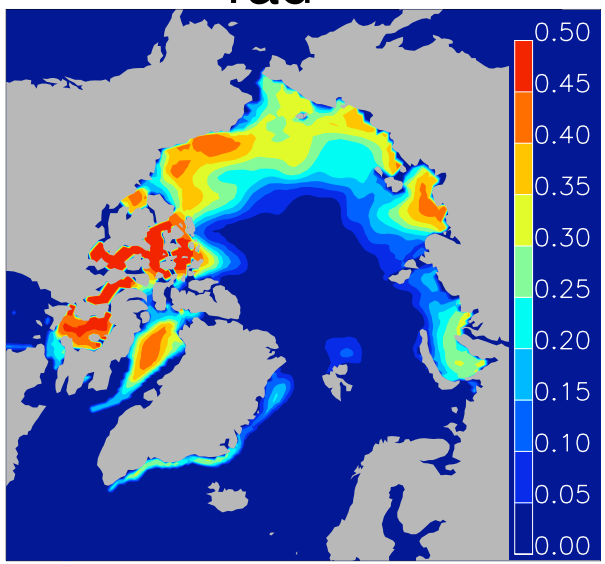
Melt Ponds in CICE: An Update

Elizabeth Hunke

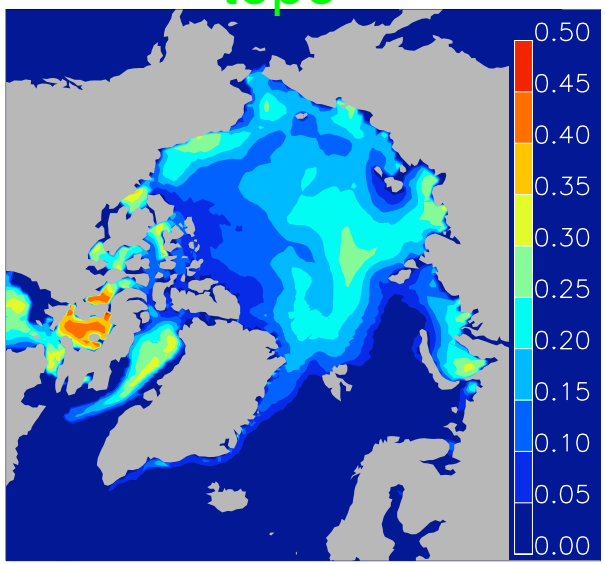
June 21, 2011

Pond fraction of ice area, July 1980–2001

rad



topo



Pond fraction of ice area, July 1980–2001

http://research.iarc.uaf.edu/belchansky_ccsm/acc2.php

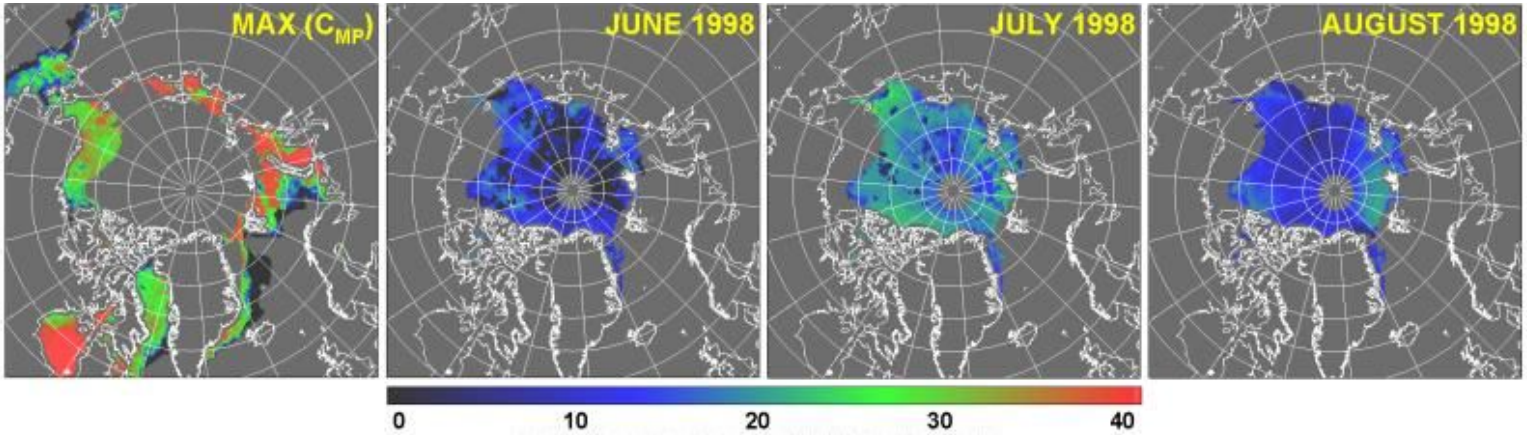
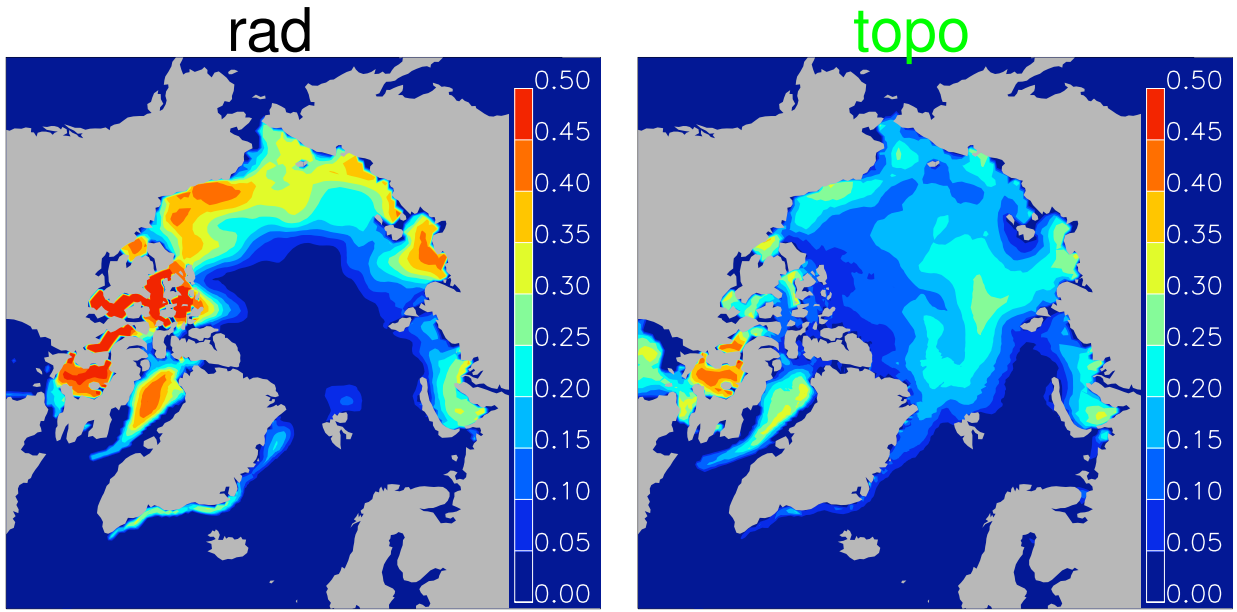


Figure 2. Peak melt pond concentrations (%) over the FY sea ice that disappeared during summer 1998 (left), and monthly mean melt pond concentrations (%) over the MY sea ice that survived in summer 1998, derived from the SHEBA-based model.



IARC Summer School, May 23 – June 4, 2011

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Olivier Lecomte

Louvain-la-Neuve University, Belgium

David Hebert

Naval Research Laboratory, Stennis Space Center

Chelsea Stephens

Purdue University

IARC Summer School, May 23 – June 4, 2011

painting by Norman Rockwell

Mark Twain Museum, Hannibal MO

- "retained" melt water fraction: $0.15 + 0.7a_i$ for $h_i > 1\,\text{cm}$
- refreezing: $V_p = V_p e^{-0.005(-2-T_{sfc})}$ for $T_{sfc} < -2^\circ$
- volume $V_p = a_p h_p$

  depth $h_p = 0.8a_p < 0.9h_i$

  area $a_p = \sqrt{V_p/0.8} < 1$
- snow $a_p^{rad} = (1 - h_s/h_{s0})\, a_p$ where $h_{s0} = 3\,\text{cm}$
- transport V_p

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  set $h_{s0} = 1\,\text{m}$, then remove altogether
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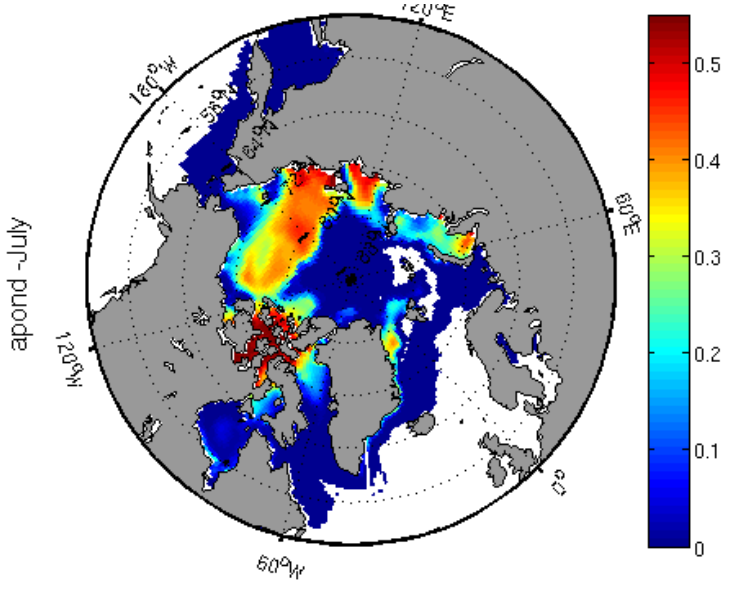
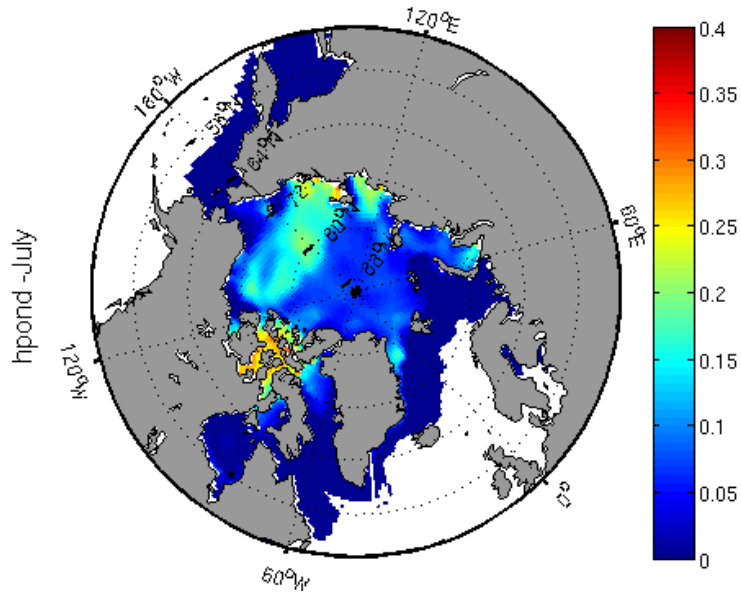
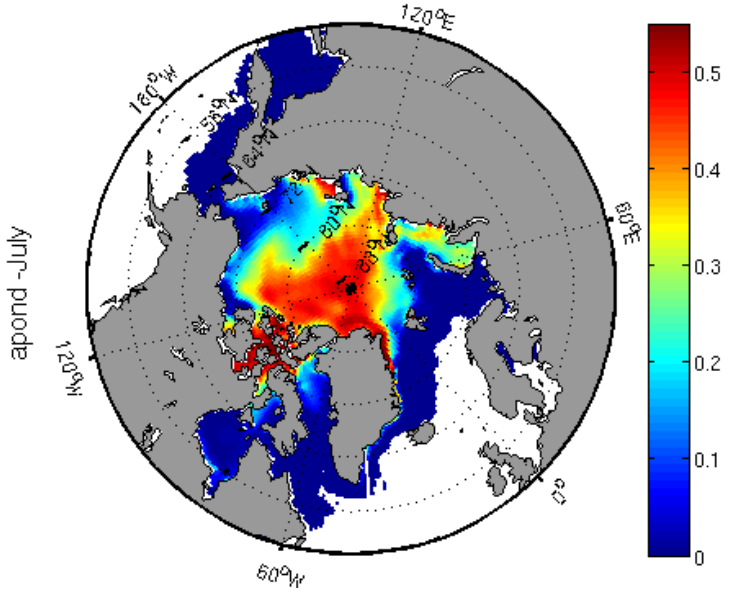
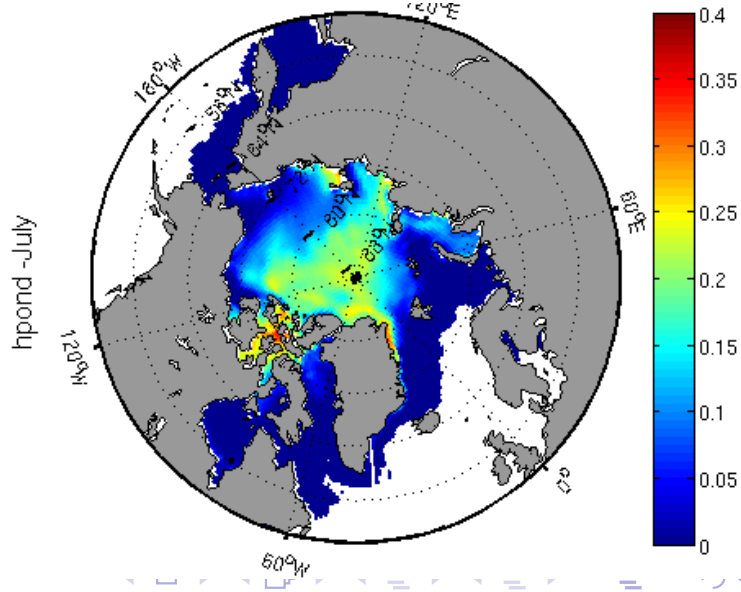
RAD Ponds

Student Experiments









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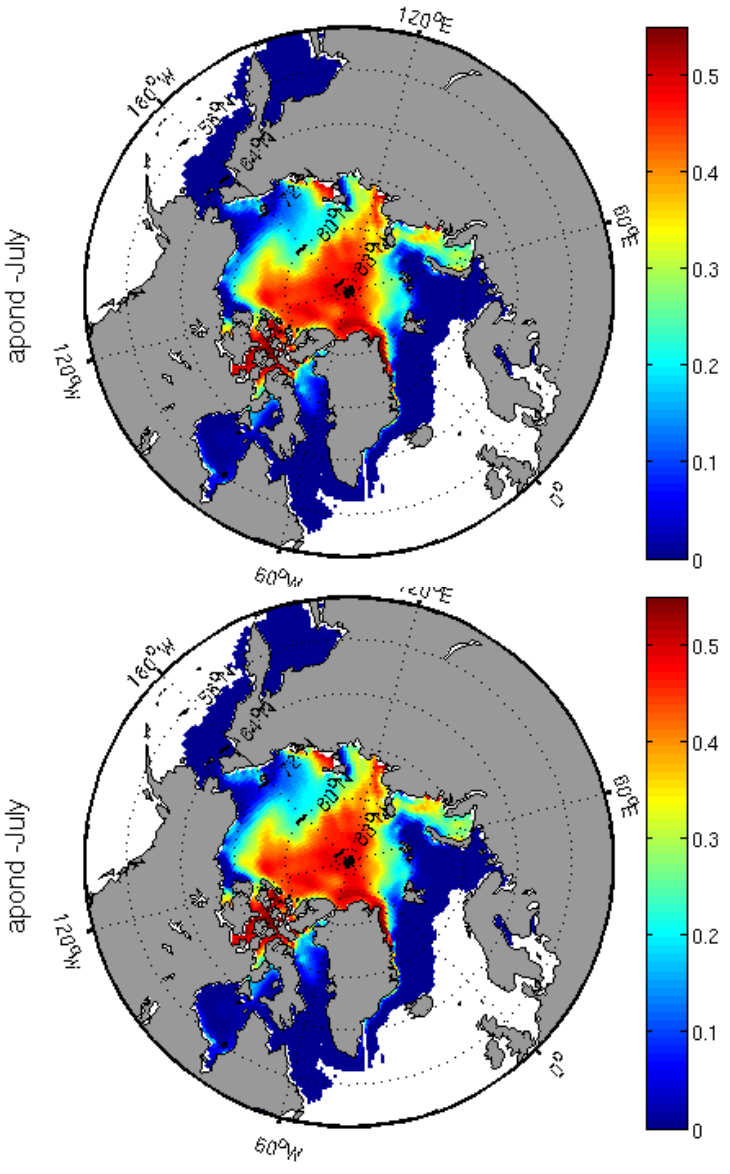

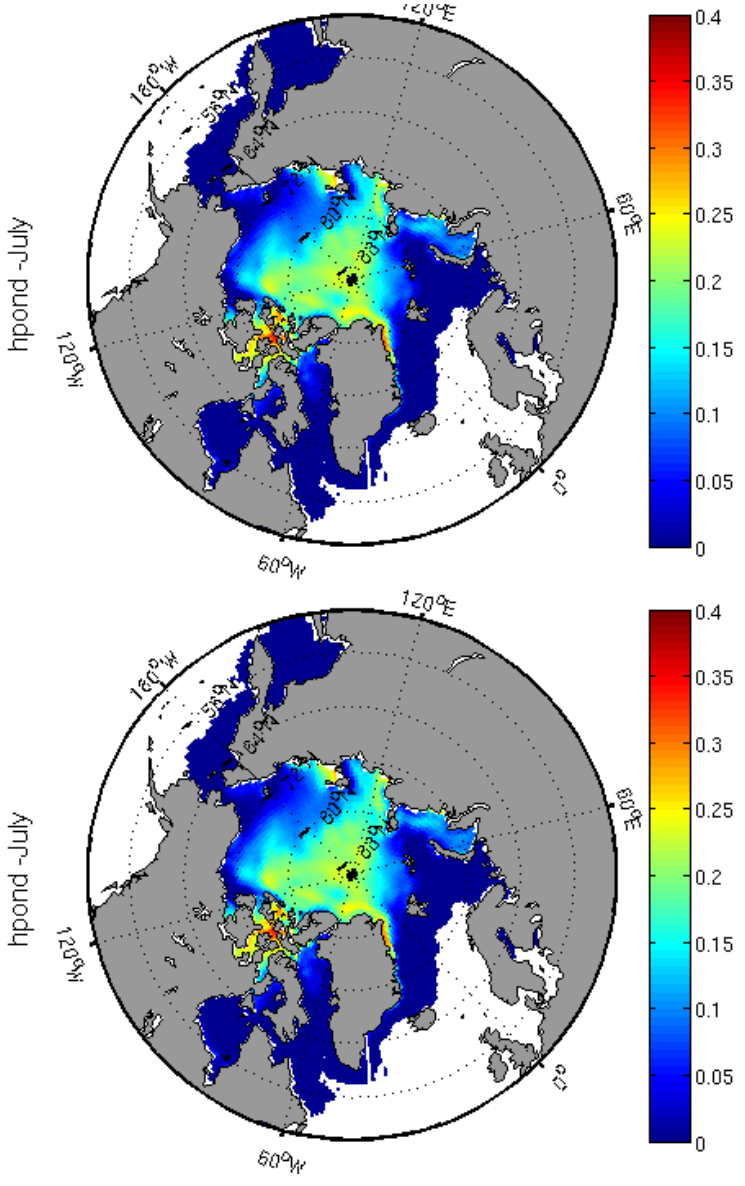

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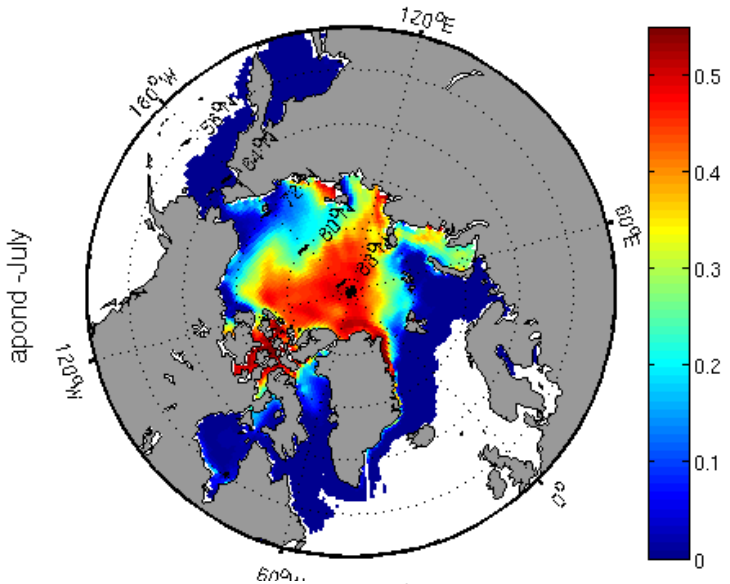

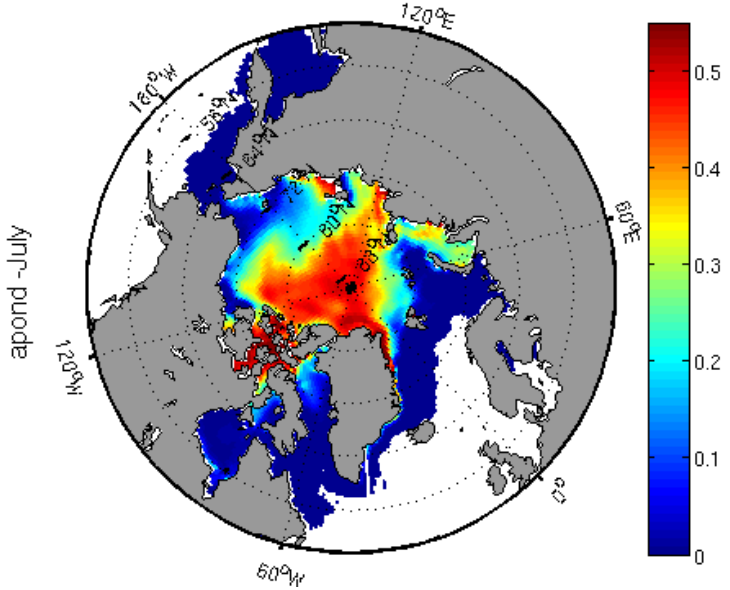

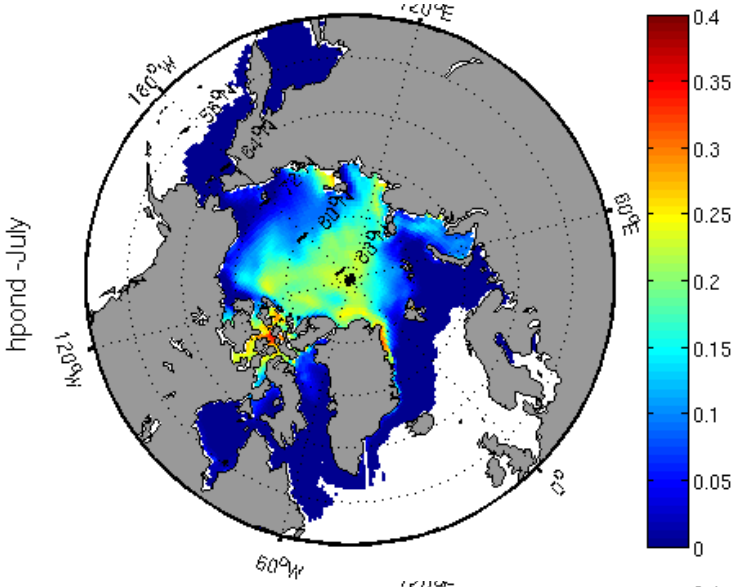

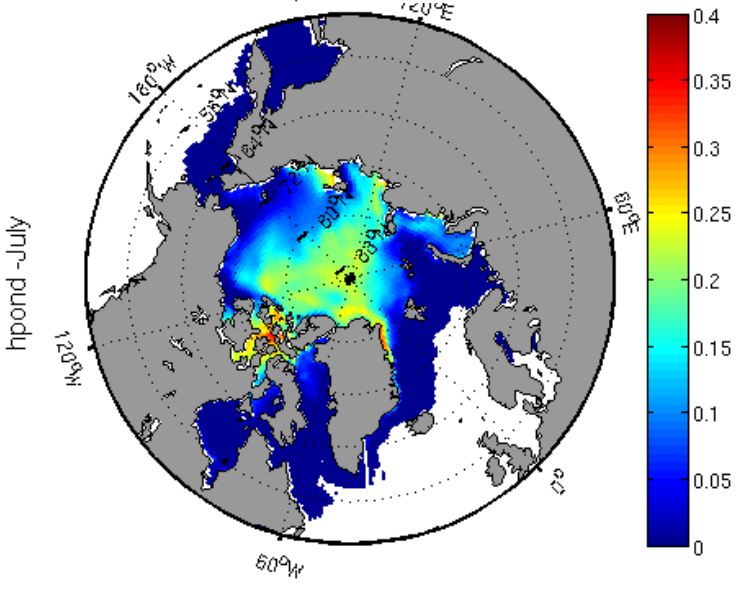

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- snow $a_p^{rad} = (1 - h_s/h_{s0})\, a_p$ where $h_{s0} = 3\,\text{cm}$
  replacement: allow ponds to infiltrate snow
- transport V_p

RAD Ponds

New Approach

- "retained" melt water fraction: $0.15 + 0.7a_i$ for $h_i > 1\,\text{cm}$
- refreezing: $V_p = V_p e^{-0.005(-2-T_{sfc})}$ for $T_{sfc} < -2^\circ$
- volume $V_p = a_p h_p$

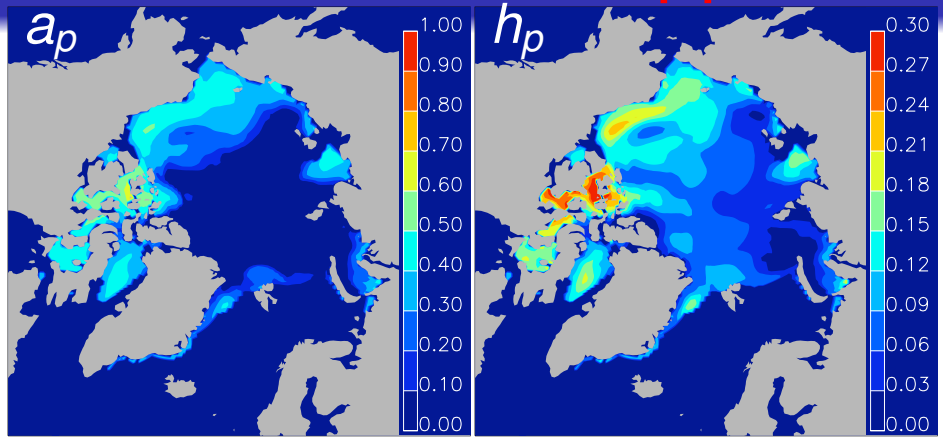
  depth $h_p = 0.8a_p \not< 0.9h_i$ X
  drain ponds on permeable ice
  area $a_p = \sqrt{V_p/0.8} < 1$
  carry ponds on level ice
- snow $a_p^{rad} = (1 - h_s/h_{s0})\, a_p$ where $h_{s0} = 3\,\text{cm}$
  ponds infiltrate snow
- transport V_p, a_p

RAD Ponds

New Approach

July 1980

original



RAD Ponds

New Approach

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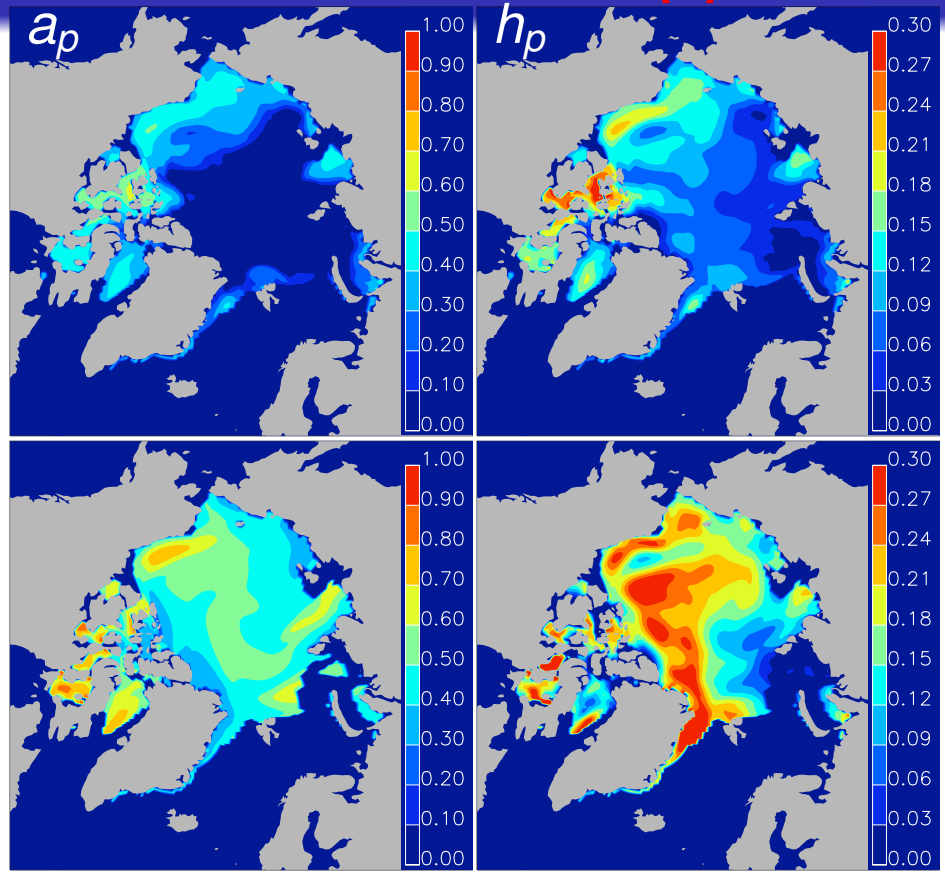
original

carry ponds on level ice



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  ponds infiltrate snow
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RAD Ponds

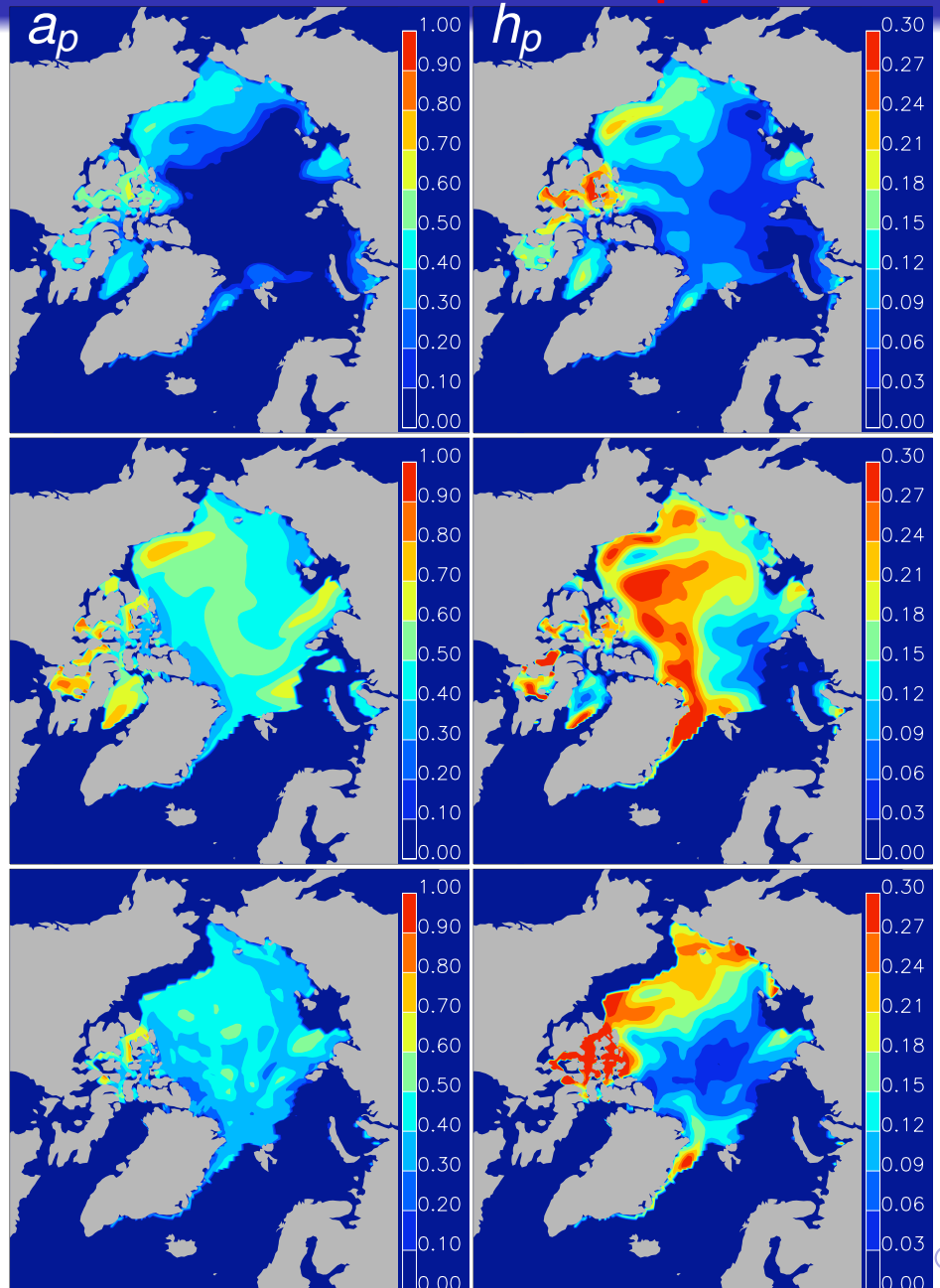
New Approach

July 1980

original

carry ponds on level ice

snow infiltration



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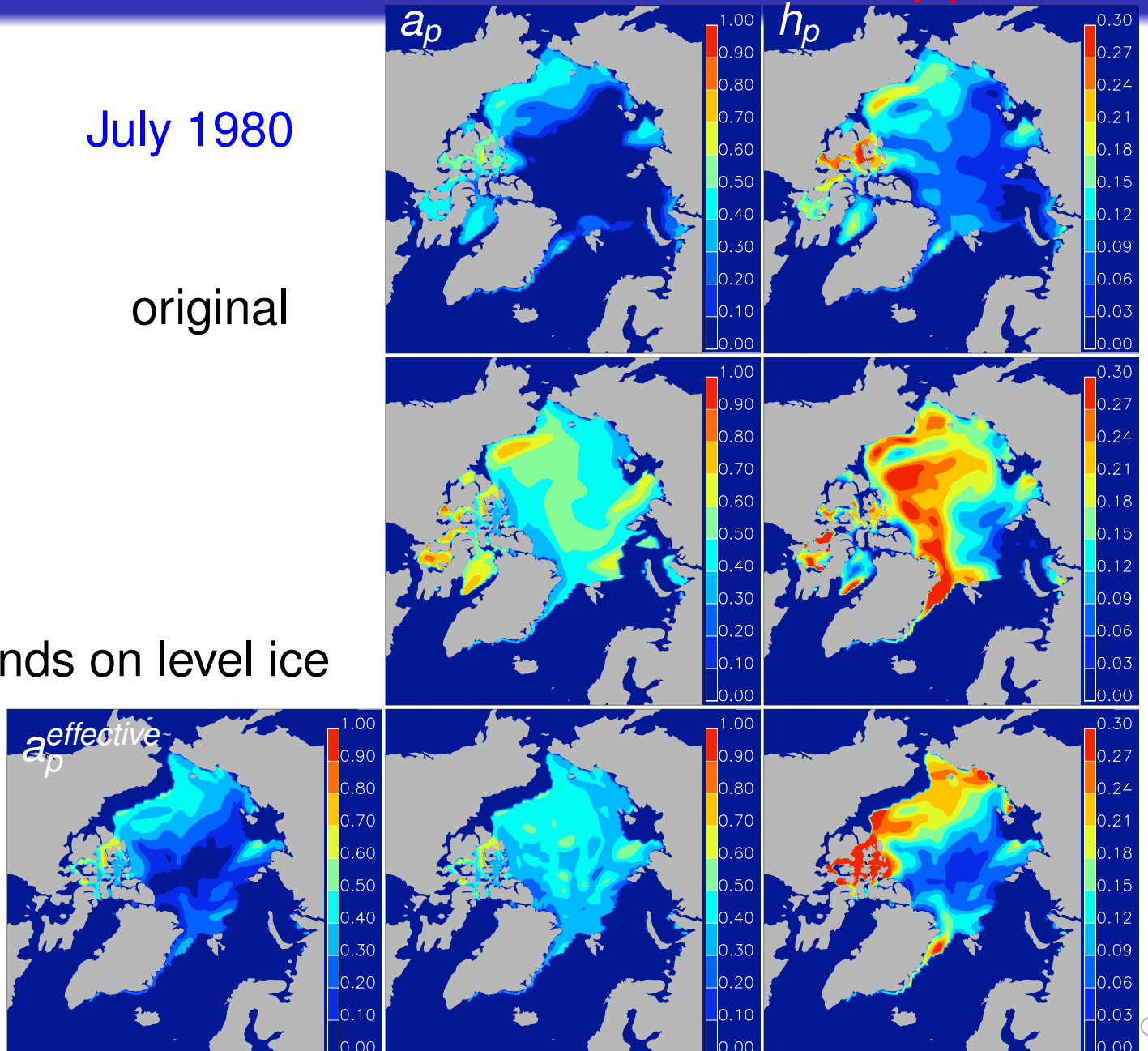

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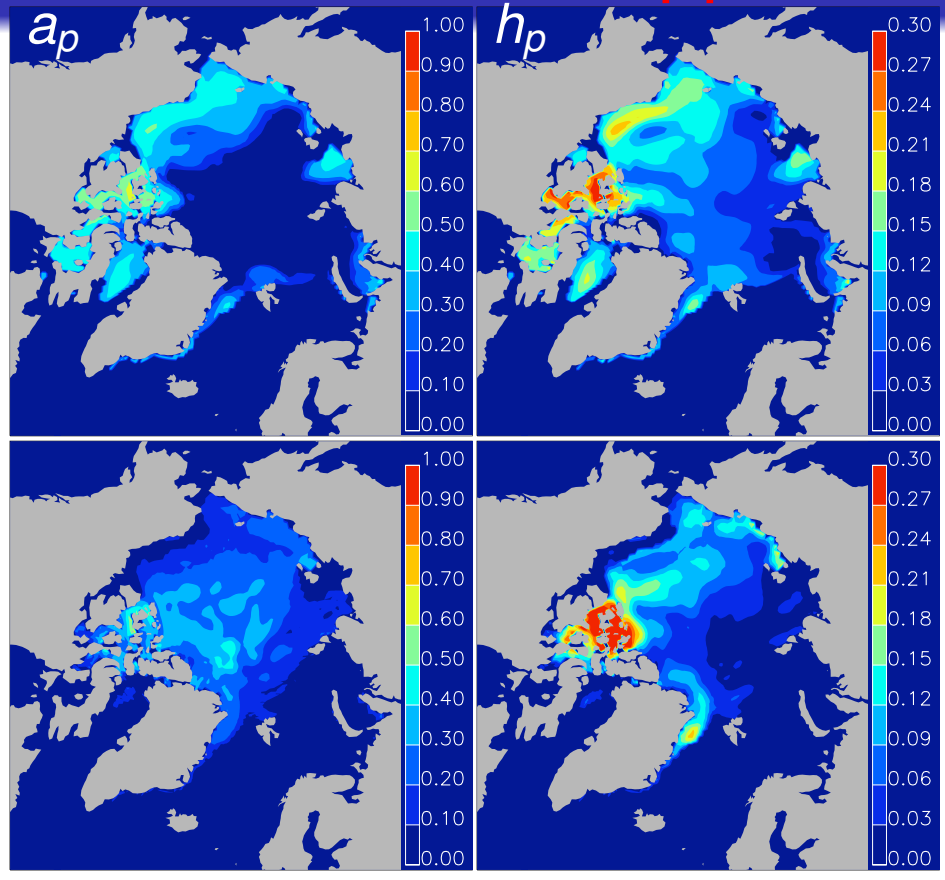

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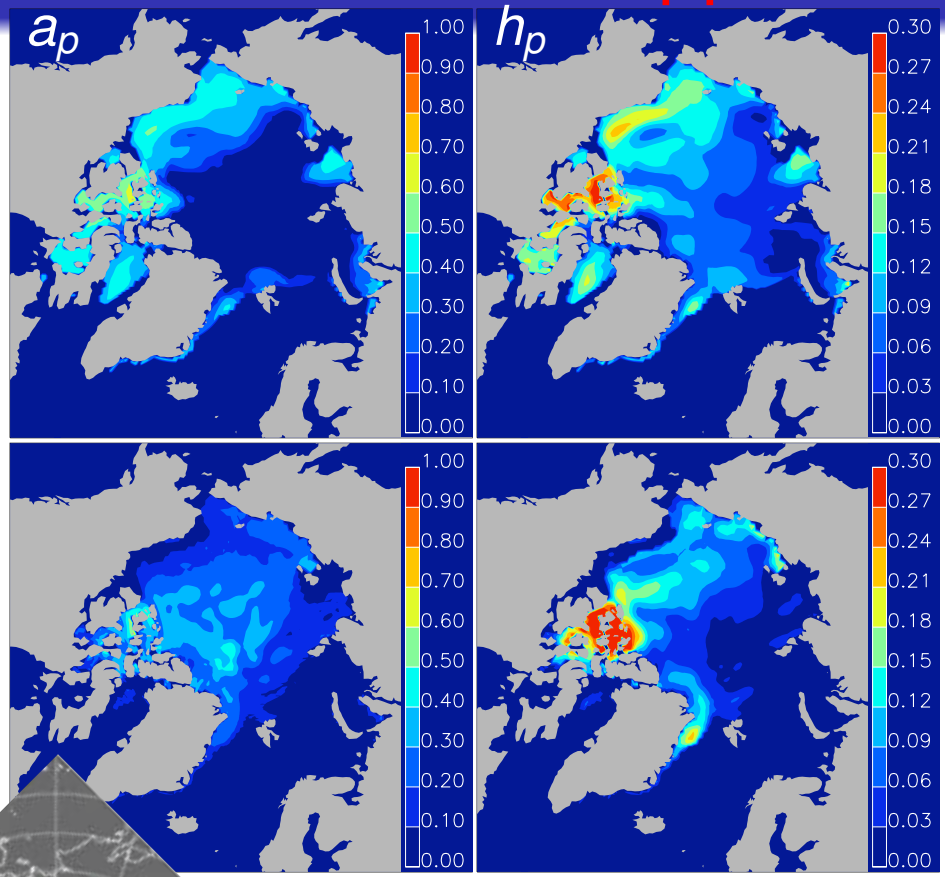

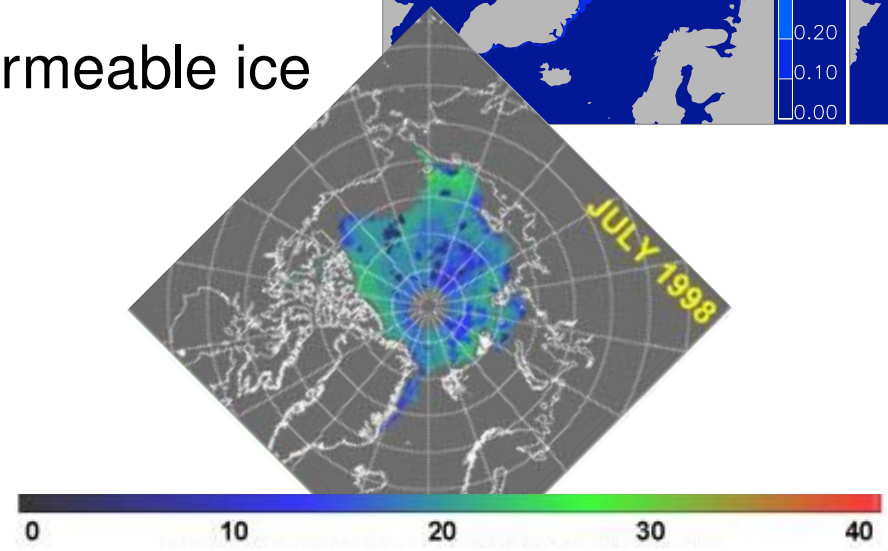

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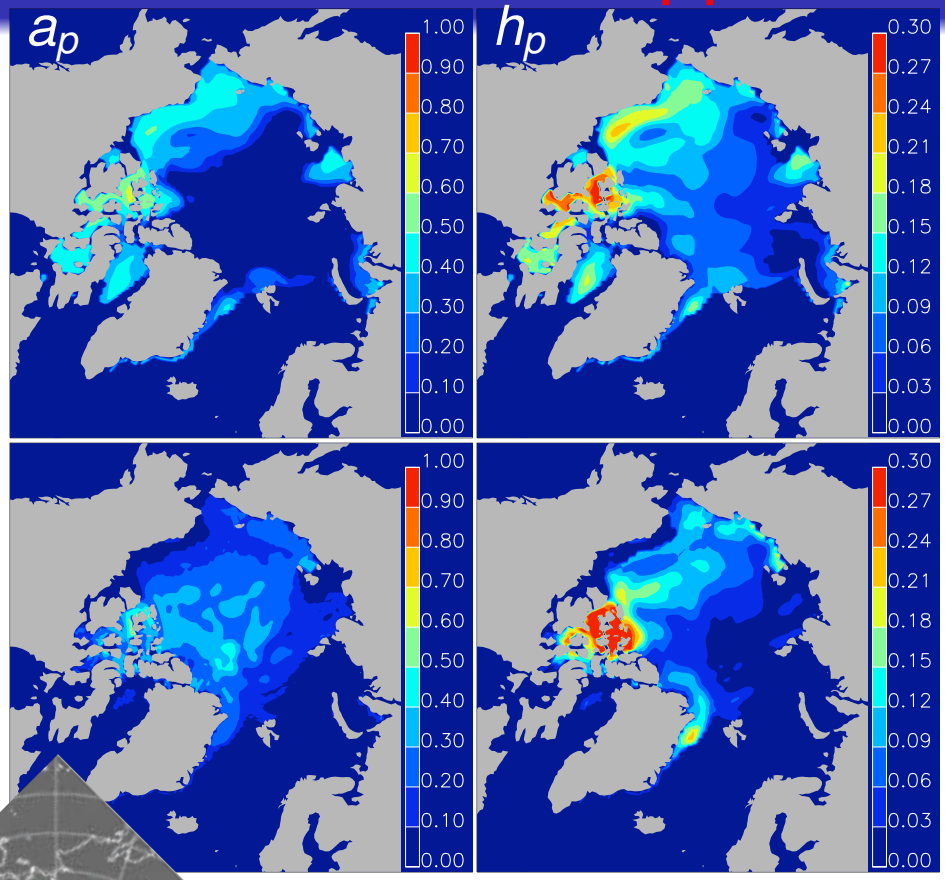
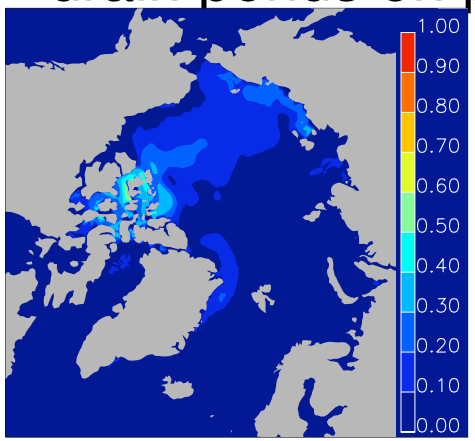
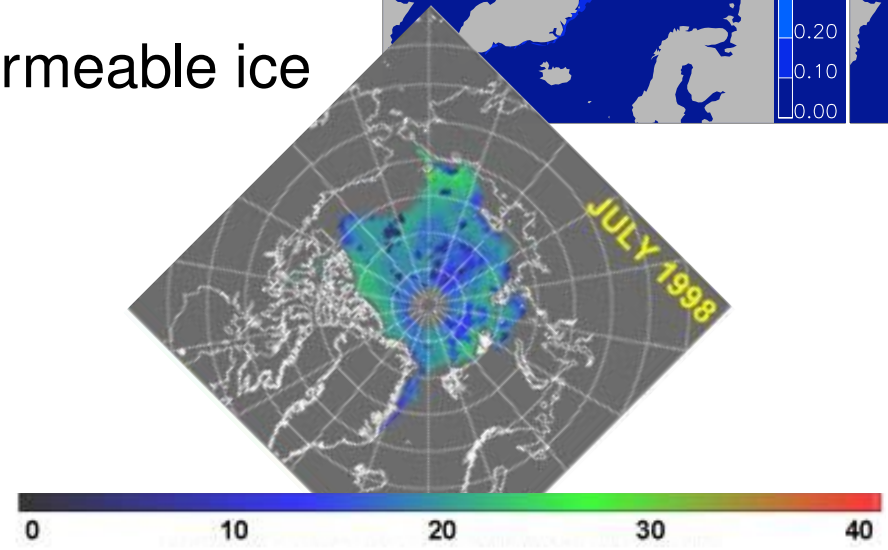


drain ponds on permeable ice





Summary ... getting there ...

Method:

1) Transport a_p as a tracer on a_{lvl} (V_p is a tracer on a_p).
2) Replace empirical formulae with physics-based descriptions,
3) using the relationship $h_p = 0.8\ a_p$ for all ΔV_p.

Caveat:

This approach requires good simulations of

1) snow depth
2) mechanical deformation (a_{lvl})

Benefits:

1) Can be made to conserve water, energy.
2) Students are still interested in working on it!