Sea ice predictability: Interannual to decadal

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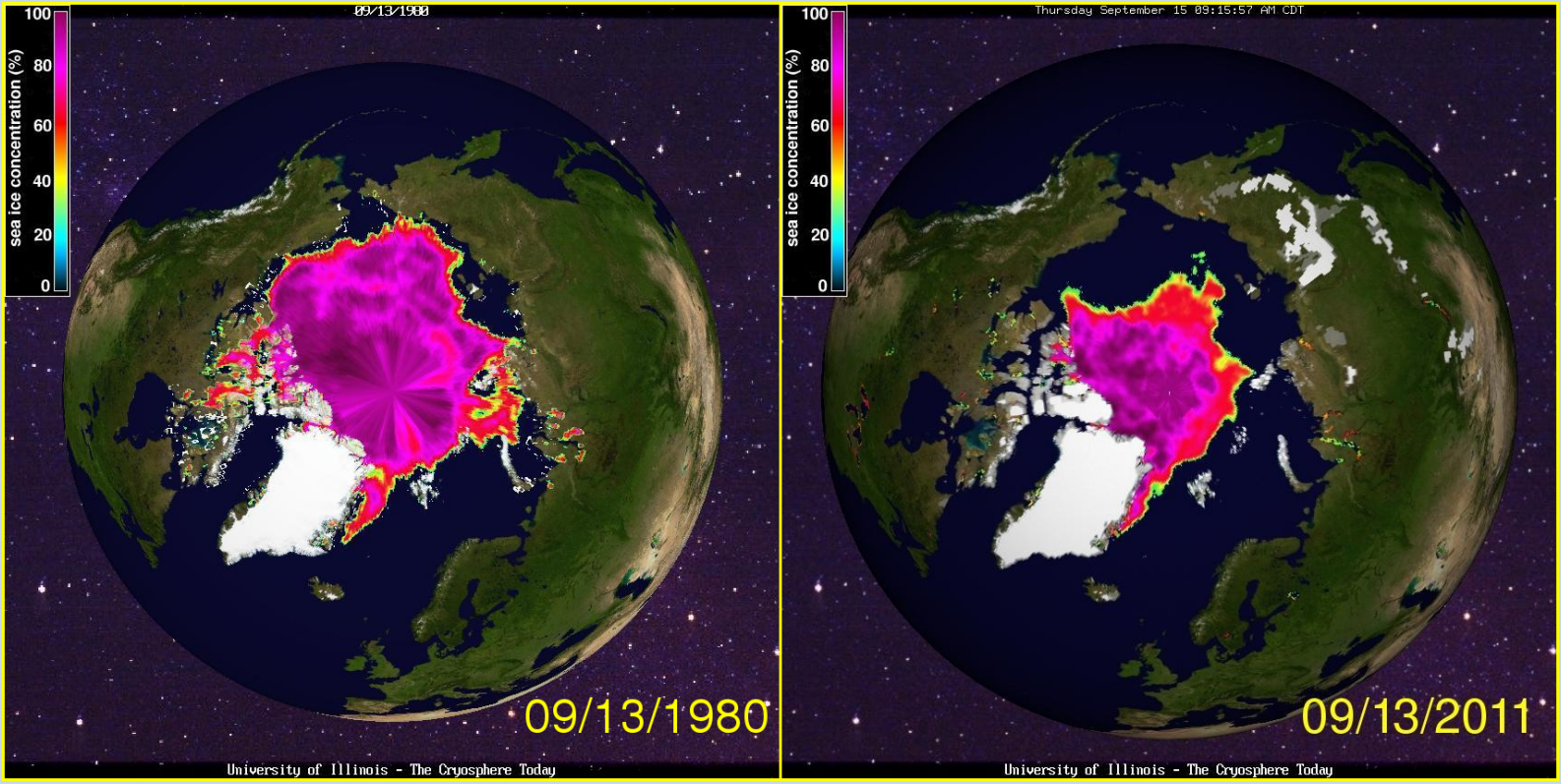


- **Present status: The only real "predictions" for decadal timescales are estimates of when the Arctic Ocean may become ice-free in summer**

- **To be reviewed here:**

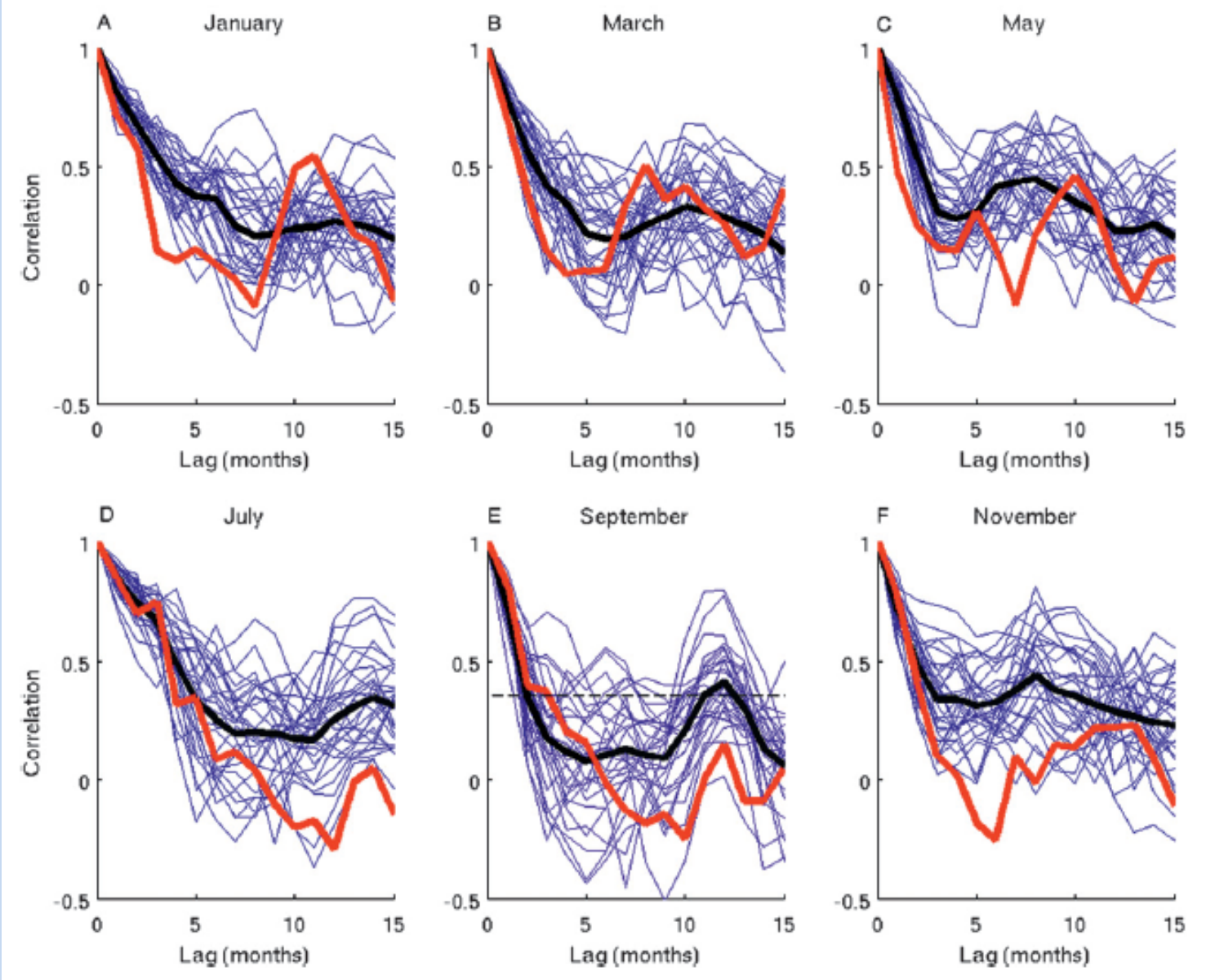
  (1) Several recent studies on the predictability of sea ice over interannual to decadal timescales

  (2) Models vs. observations

Monthly lagged autocorrelations of ice area from indicated months

red = observed*, *blue = CCSM model*, *black = model ensemble mean

[from Blanchard-Wrigglesworth et al., 2011a, GRL]



Blanchard-Wrigglesworth, Armour, Bitz & DeWeaver (2011a, GRL) relevant findings on *persistence-derived predictability*:

- **Lagged correlations of sea *ice area and extent* anomalies are generally consistent in observations and the CCSM model – although "memory" tends to be greater in model.**

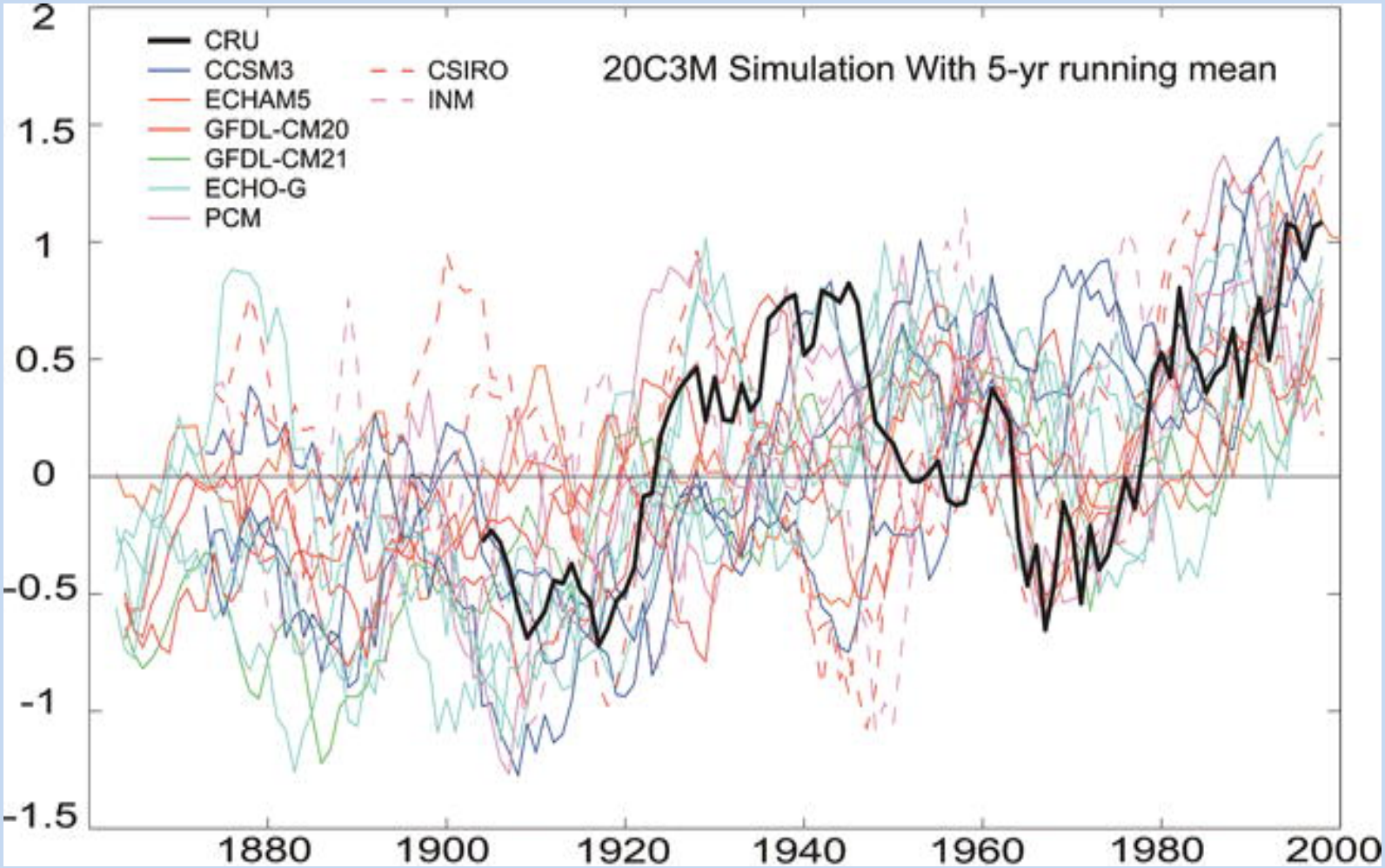
- **Significant autocorrelations (memory) are generally lost within 2-5 months for ice *area and extent*, with two exceptions:**

  (1) summer-to-summer persistence arising from persistence of thickness anomalies and influence on ice area

  (2) anomalies in growth season arising from melt season, attributable to persistence of SST anomalies in marginal ice zone

20th-century Arctic (60-90°N) temperatures simulated by individual IPCC models

[from M. Wang et al., 2007, J. Climate]



Community Climate System Model (CCSM4) can reproduce observed 1979-2005 Arctic sea ice loss

[from Kay et al., 2011, GRL]

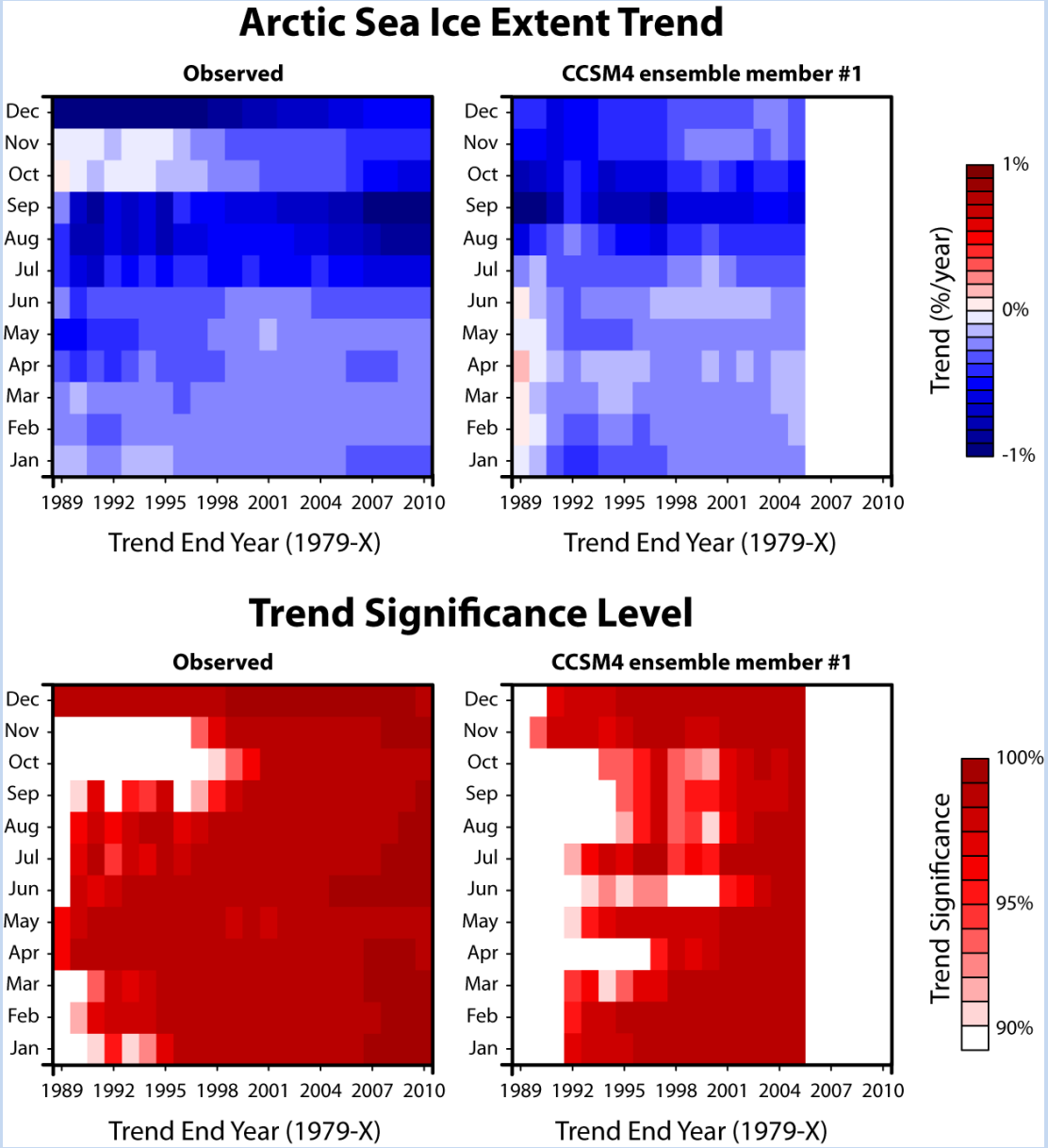


Figure modified from
Kay, Holland, and Jahn (2011)

…but the six available CCSM4 ensemble members exhibit a large spread in their late 20th century ice extent loss.

[Kay et al., 2011]

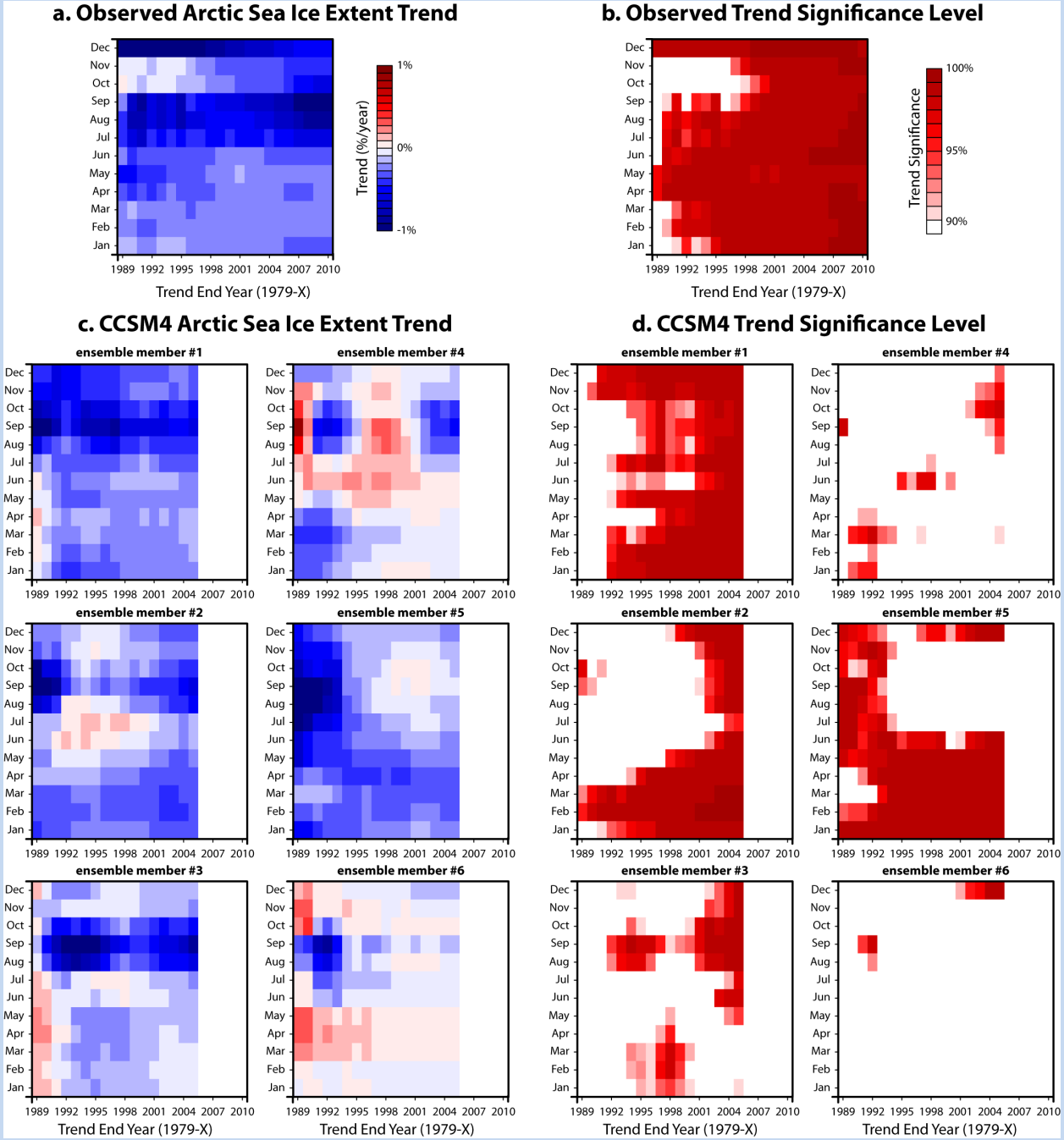
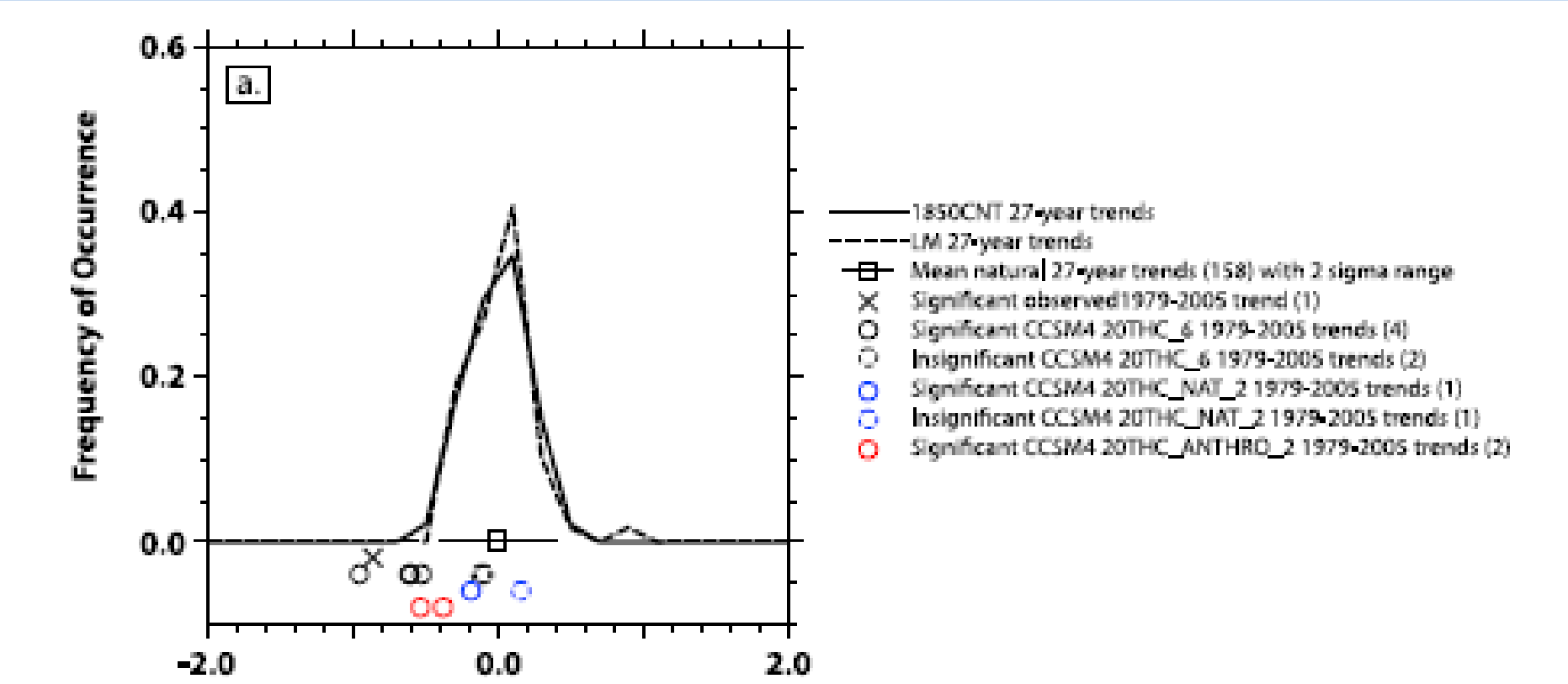


Figure 1, Kay, Holland, and Jahn (2011)

Distribution of 27-year (1979-2005) trends of September ice extent

X = observed, O = 20th-century CCSM model run

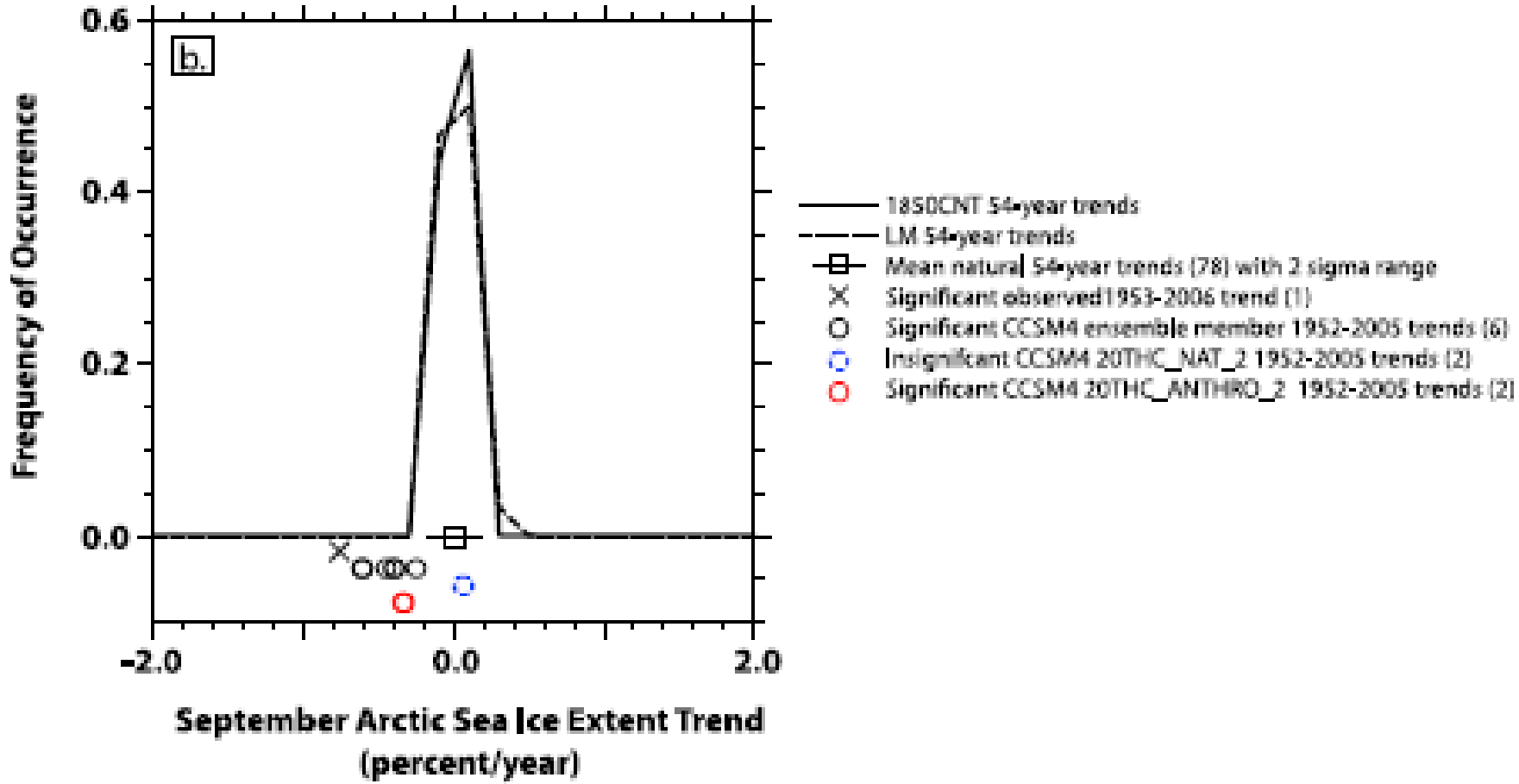
[from Kay et al., 2011]

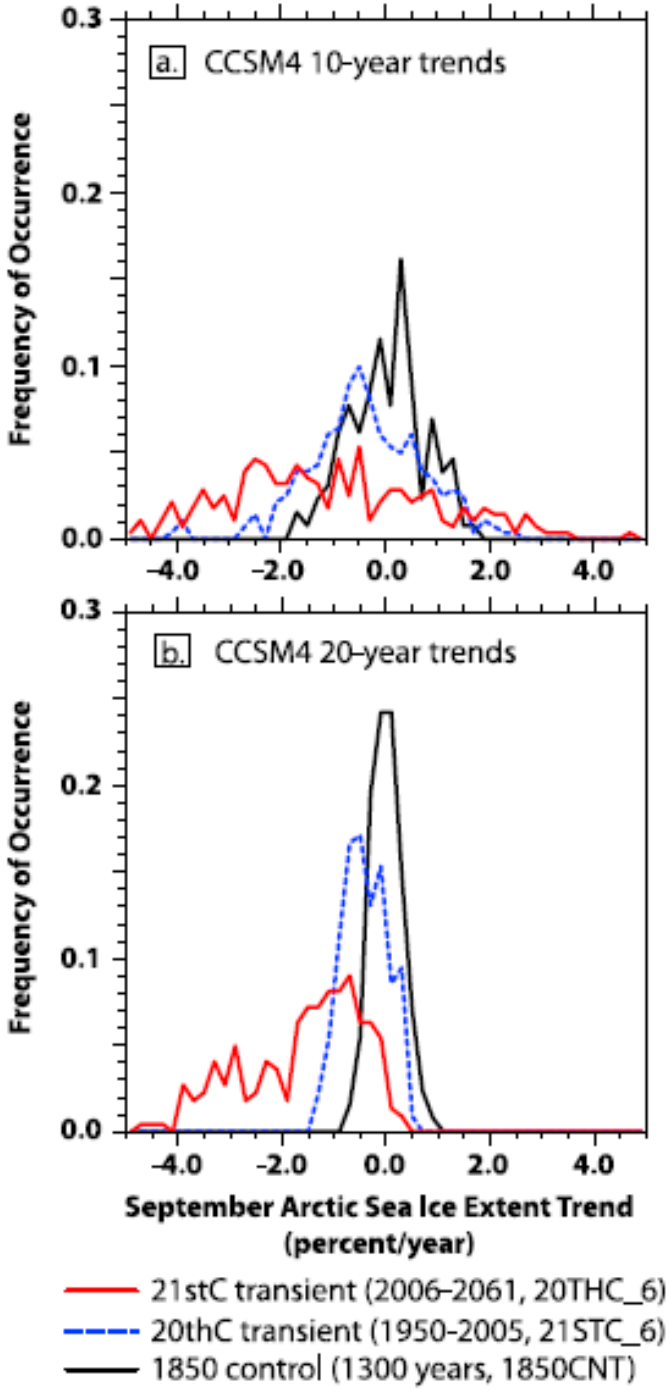


Distribution of 54-year (1953-2006) trends of September ice extent

X = observed, O = 20th-century CCSM model run

[from Kay et al., 2011]





← *10-year trends*

Distribution of trends in CCSM4 simulations – transient and control

← *20-year trends*

[From Kay et al., 2011, GRL]

Kay et al (2011, GRL) relevant findings:

- **Internal variability explains about half the pan-Arctic loss of sea ice, 1979-2005.**

- **On all timescales examined (2-50+ years), the most extreme negative trends of recent decades cannot be explained by modeled natural variability alone.**

- **In a warming world, multiyear-to-decadal trend variability increases in the CCSM4 model. Positive trends on 2-20 year timescales occur until the mid-21st century.**

Blanchard-Wrigglesworth, Bitz and Holland (2011b, GRL)

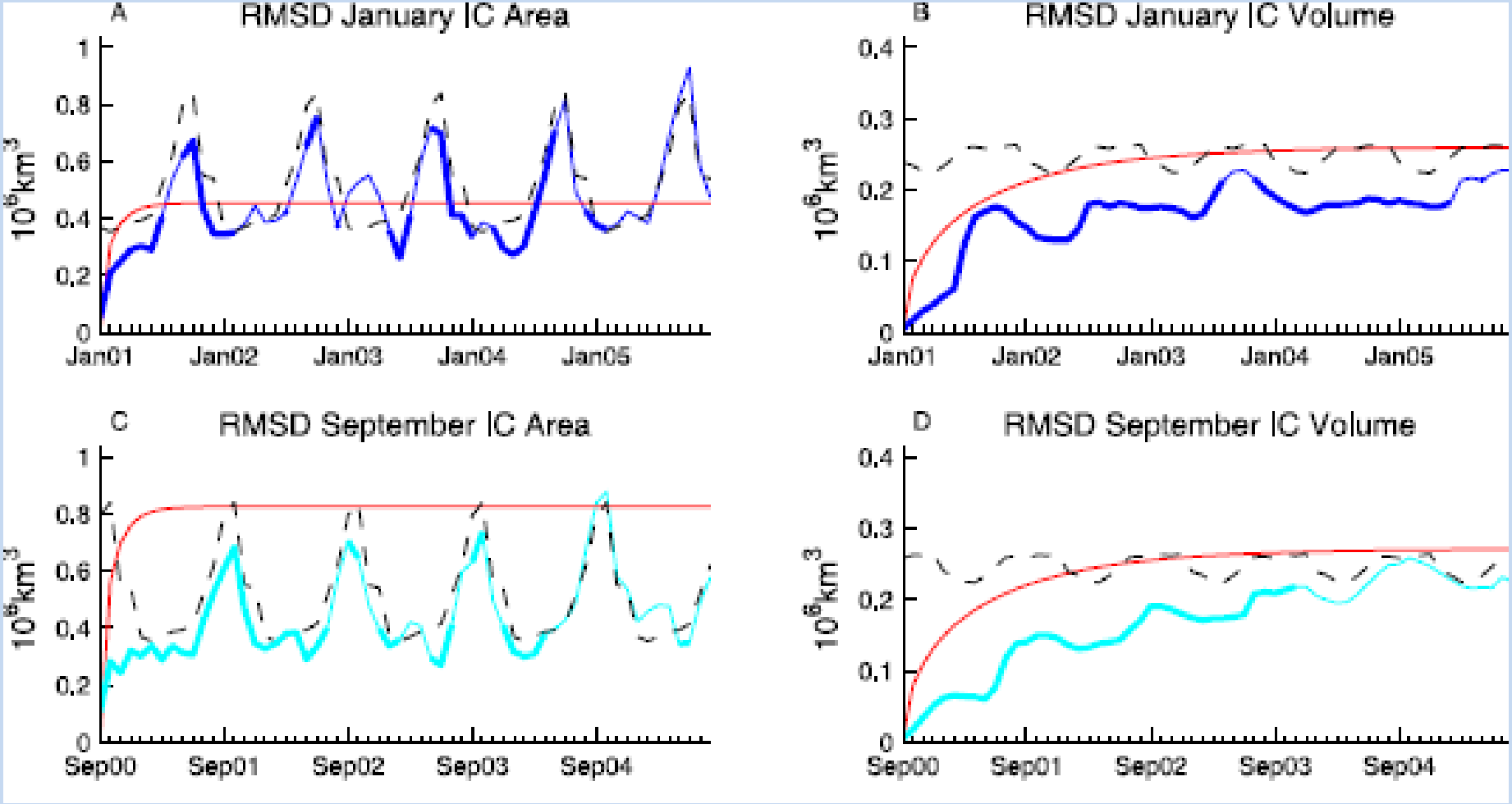
- **Important distinction:**

  predictability of the first kind: from initial conditions

  predictability of the second kind: from boundary conditions (including external forcing)

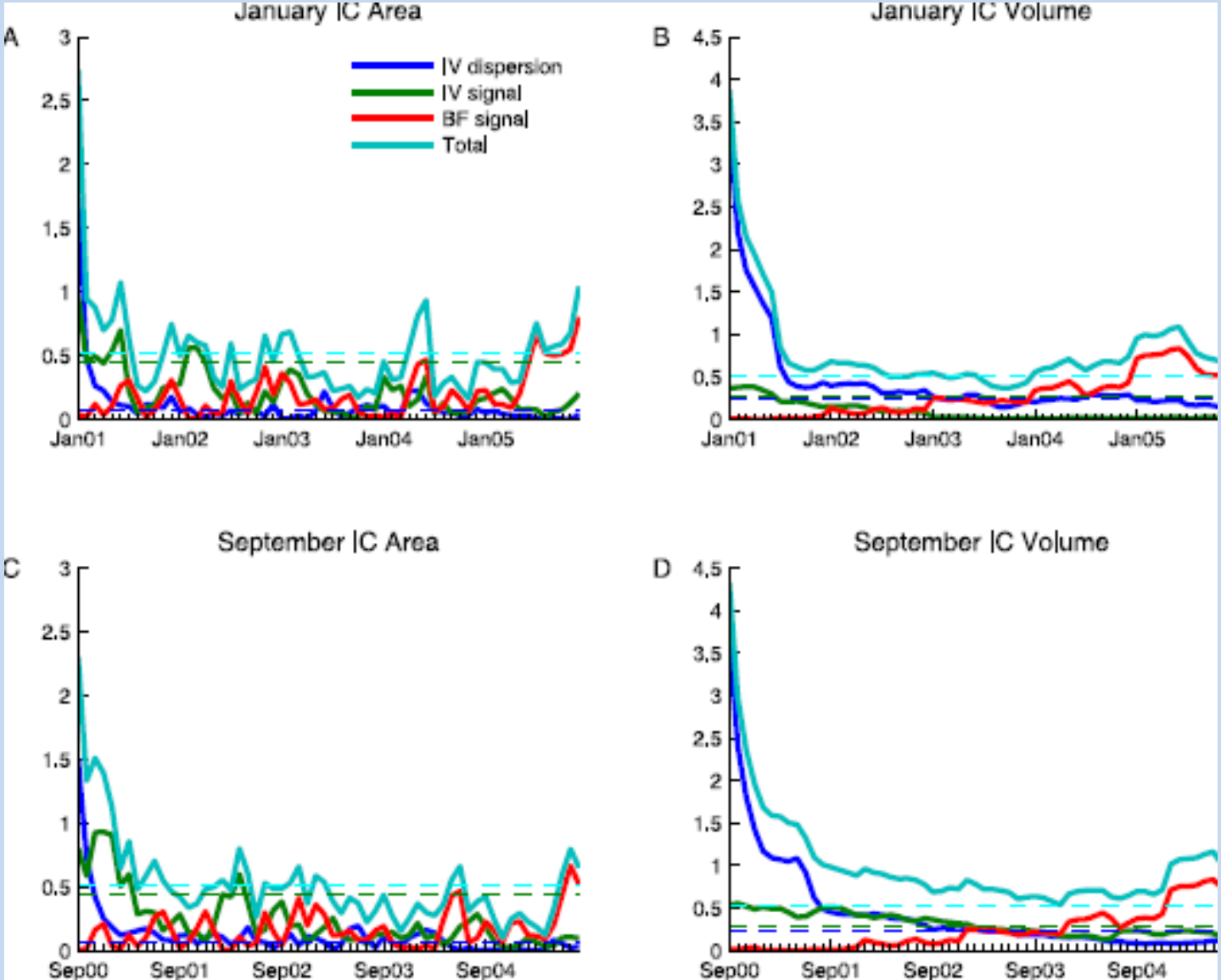
Root mean square difference (error) – solid lines
vs.
corresponding simulation with no predictability (dashed lines)

[from Blanchard-Wrigglesworth et al., 2011b, GRL]



Information provided by prediction over climatology ("relative entropy") from internal variability (dark green) and forcing (red)

[Blanchard-Wrigglesworth et al., 2011b, GRL]



Blanchard-Wrigglesworth, Bitz and Holland (2011b, GRL) relevant findings:

- **Important distinction:**

  predictability of the first kind: from initial conditions

  predictability of the second kind: from boundary conditions (including external forcing)

- **For ice area, initial-value predictability of pan-Arctic sea ice is continuous for 1-2 years, intermittent to 2-4 years (area-thickness coupling)**

- **For pan-Arctic ice volume, initial-value predictability is significant out to 3-4 years**

- **Beyond 3-4 years, predictability is dominated by climate forcing**

Summary: key points ⇒ needs

- **Beyond a few seasons, sea ice prediction skill is presently low -- at best.**

- **Models show some promise at capturing variance and trends**

  ⇒ research needed with larger sample of models and observational data to determine whether models indeed capture the spectrum of relevant sea ice variability

- **Deterministic skill (predictability of the first kind) has yet to be achieved operationally at ranges of 1 to 2 years**

  ⇒ ice-ocean models, fully coupled (CFS) models need to target the range beyond a season or two

- **Since uncertainties will be large even if some skill is achieved, probabilistic framework is likely needed for interannual-to-decadal outlooks**

  ⇒ need to interface with users to establish utility, formats, etc.