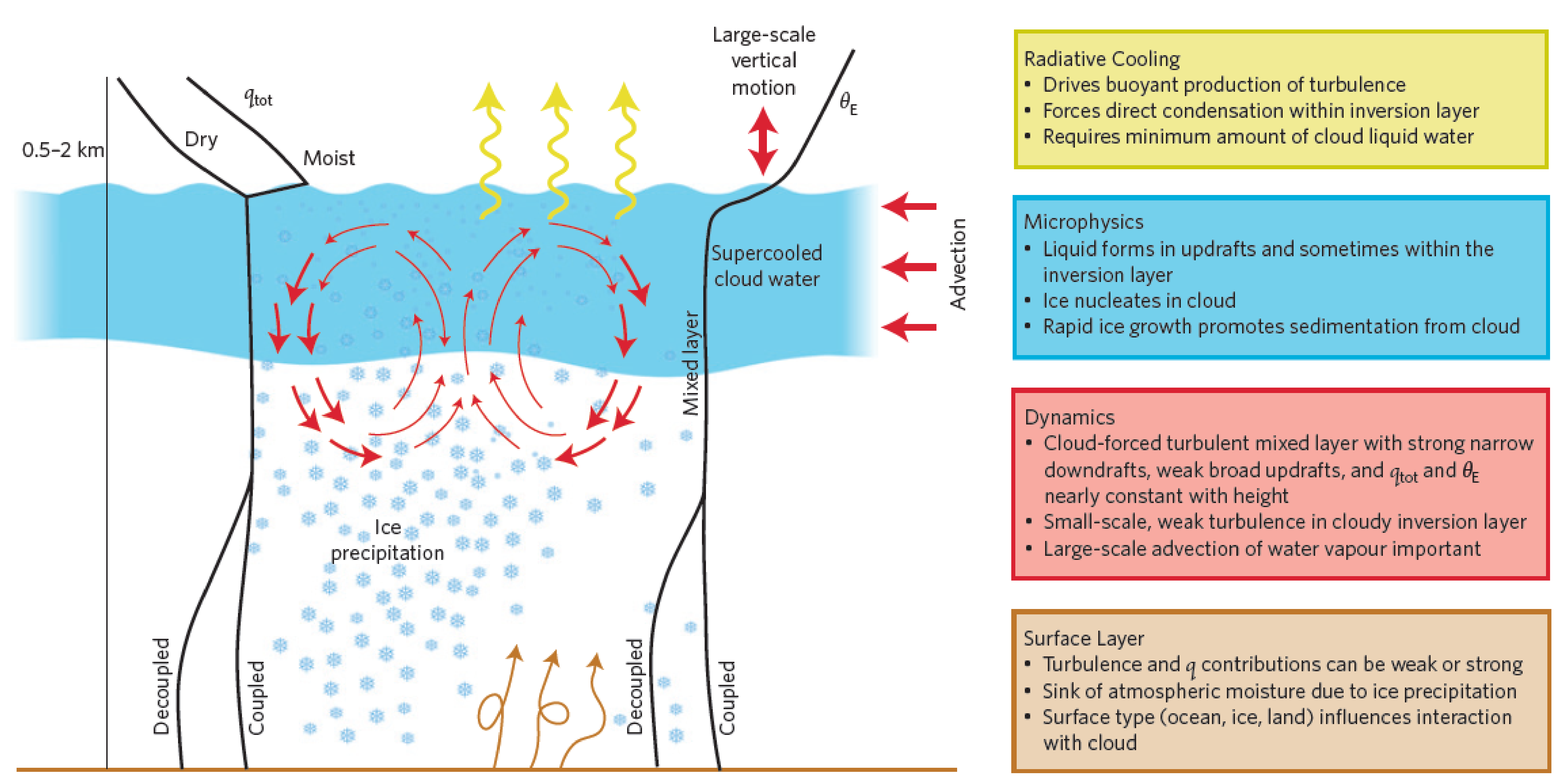
Unclouding drivers of Arctic sea ice loss



Radiative Cooling
- Drives buoyant production of turbulence
- Forces direct condensation within inversion layer
- Requires minimum amount of cloud liquid water

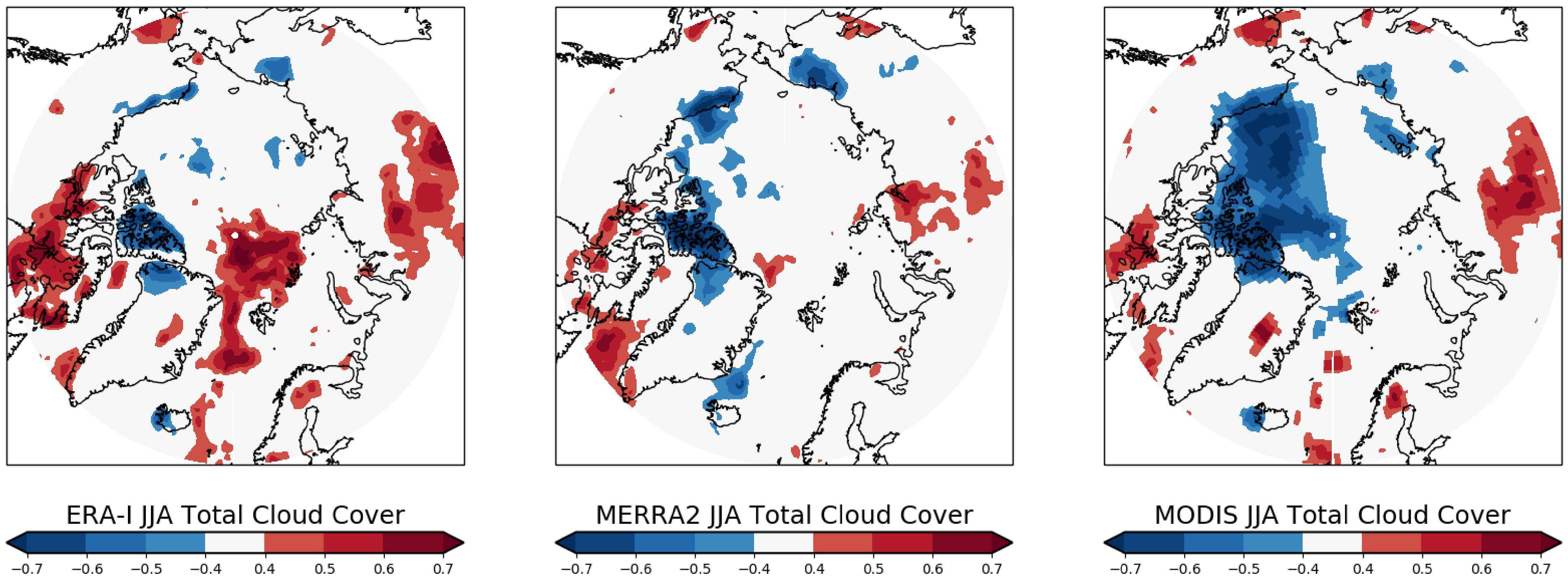
Microphysics
- Liquid forms in updrafts and sometimes within the inversion layer
- Ice nucleates in cloud
- Rapid ice growth promotes sedimentation from cloud

Dynamics
- Cloud-forced turbulent mixed layer with strong narrow downdrafts, weak broad updrafts, and q_{tot} and θ_E nearly constant with height
- Small-scale, weak turbulence in cloudy inversion layer
- Large-scale advection of water vapour important

Surface Layer
- Turbulence and q contributions can be weak or strong
- Sink of atmospheric moisture due to ice precipitation
- Surface type (ocean, ice, land) influences interaction with cloud

Figure 3 | A conceptual model that illustrates the primary processes and basic physical structure of persistent Arctic mixed-phase clouds. The main features are described in text boxes, which are colour-coded for consistency with elements shown in the diagram. Characteristic profiles are provided of total water (vapour, liquid and ice) mixing ratio (q_{tot}) and equivalent potential temperature (θ_E). These profiles may differ depending on local conditions, with dry versus moist layers/moisture inversions above the cloud top, or coupling versus decoupling of the cloud mixed layer with the surface. Cloud-top height is 0.5–2 km. Although this diagram illustrates many features, it does not fully represent all manifestations of these clouds.

Resilience of persistent Arctic mixed-phase clouds, Morrison et al (2011), Nature Geoscience



ERA-I JJA Total Cloud Cover

MERRA2 JJA Total Cloud Cover

MODIS JJA Total Cloud Cover

Correlation of ERA-I (a), MERRA-2 (b), and MODIS (c) total cloud cover with Arctic-averaged (70-90N) 300 hPa stream function (2000-2018). Positive correlation represents upper level anticyclonic motion coinciding with increased total cloud cover.

Clouds modulate surface radiative fluxes that melt Arctic sea ice.

During summer, formation and persistence of these Arctic clouds is not a response to changing surface conditions, but rather the overlying circulation regime.

However, the cloud response to circulation varies between products.

Can we utilize model experiments to help us constrain the cloud response and thus sea ice loss associated with circulation changes?

Let's discuss!

Ian Baxter,
Masters Student,
University of
California Santa
Barbara

ERI Earth Research Institute

UCSB