NCAR

Cloud diagnostics in subsidence regions: comparison of the NCAR and GFDL models versus observations and reanalysis

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Motivation

- B. Soden: impact of low and high clouds on climate sensitivity.

- NCAR and GFDL models: change in low-level clouds for a $2xCO_2$ scenario was very different in the 2 models
⇒ large impact on climate sensitivity

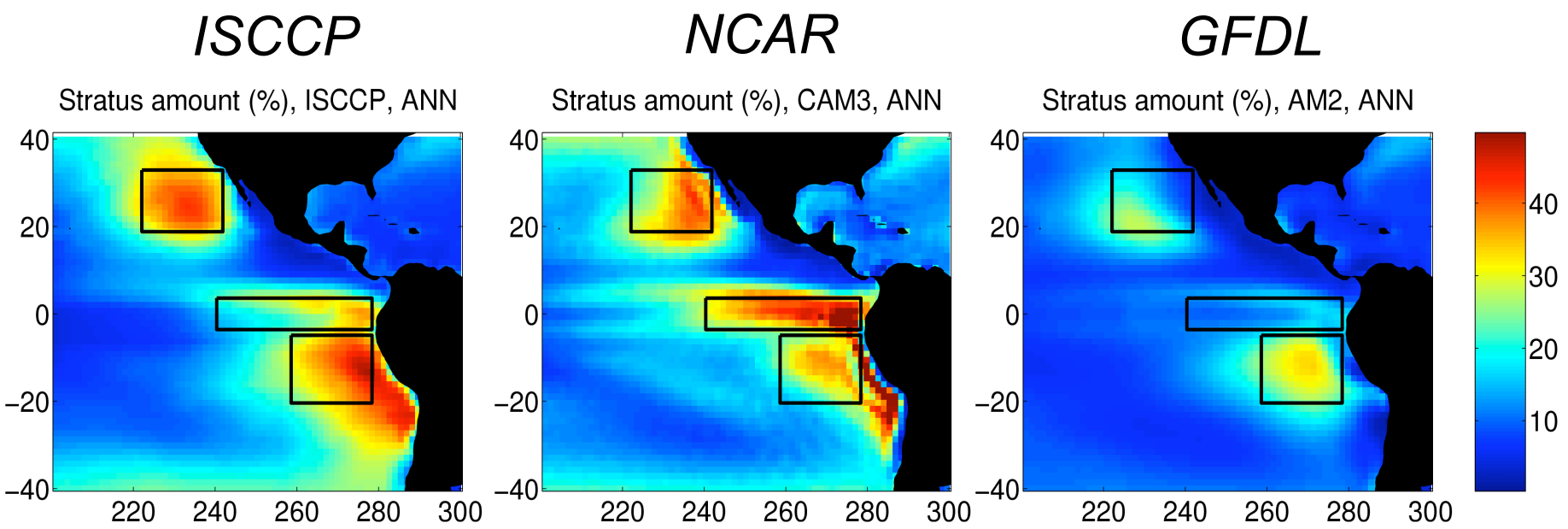
- Here: we compare present day climate runs of the 2 models versus observations and reanalysis in stratocumulus regions.

To better understand:
what determine the cloud properties in these regions ?
how well the models represent these stratocumulus zones ?

Climatological datasets

- NCAR model (CAM3): AMIP run, T85 resolution , 1979-1999
- GFDL model (AM2p12): AMIP run, 2 x 2.5 resolution, 1983-1998
- Observations and reanalysis:
  - ISCCP, stratocumulus clouds, 1983-1999
  - SSM/I, liquid water path, 1987-2000
  - ERBE, shortwave cloud forcing, 1985-1989
  - HadISST: sea surface temperature, 1979-1999
  - ECMWF reanalysis (ERA40): T, q, w, surface fluxes, 1979-1999

Eastern Pacific Stratocumulus: models versus ISCCP

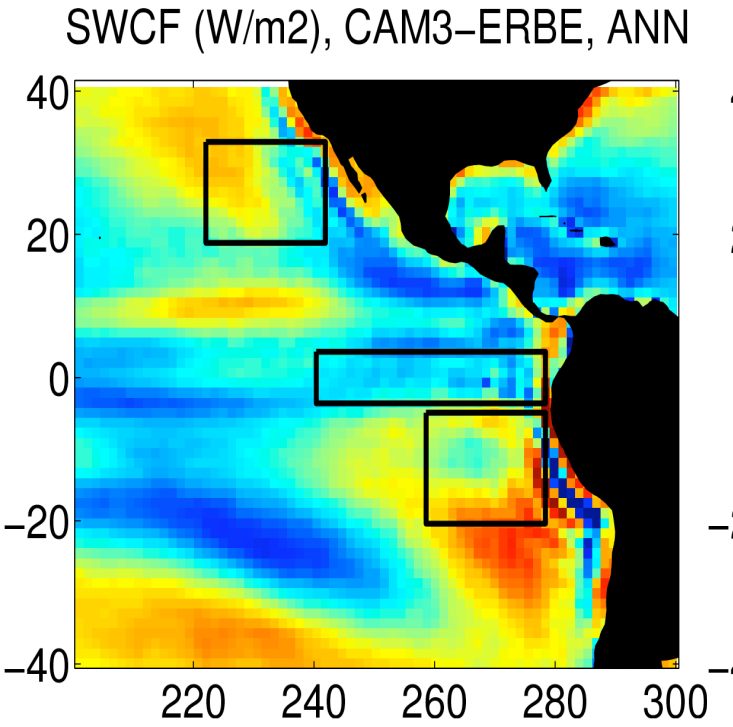


- NCAR model: - clouds too close from the coast
  - over-predicts clouds in East Equatorial zone

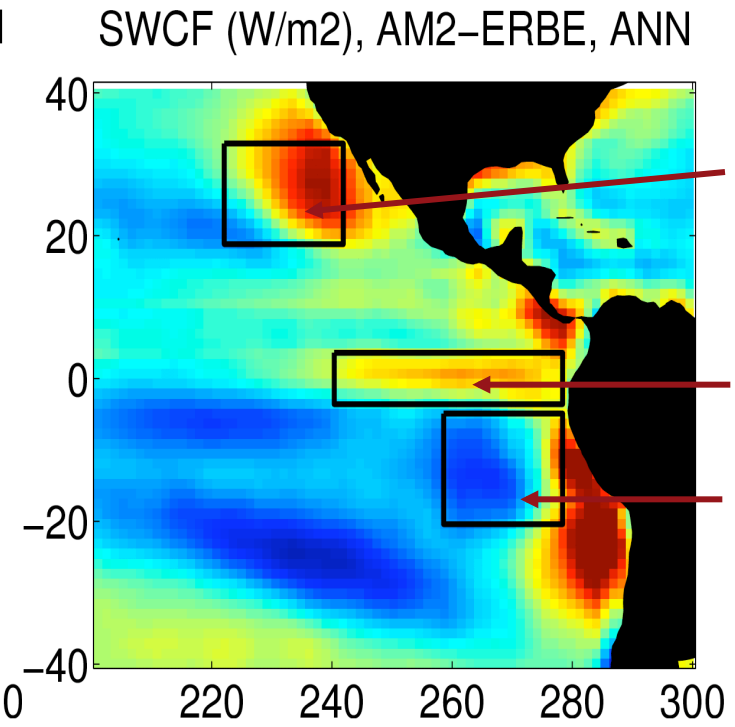
- GFDL model: - underestimates stratocumulus
  - clouds too far from the coast

Error on SWCF: models versus ERBE

NCAR



GFDL



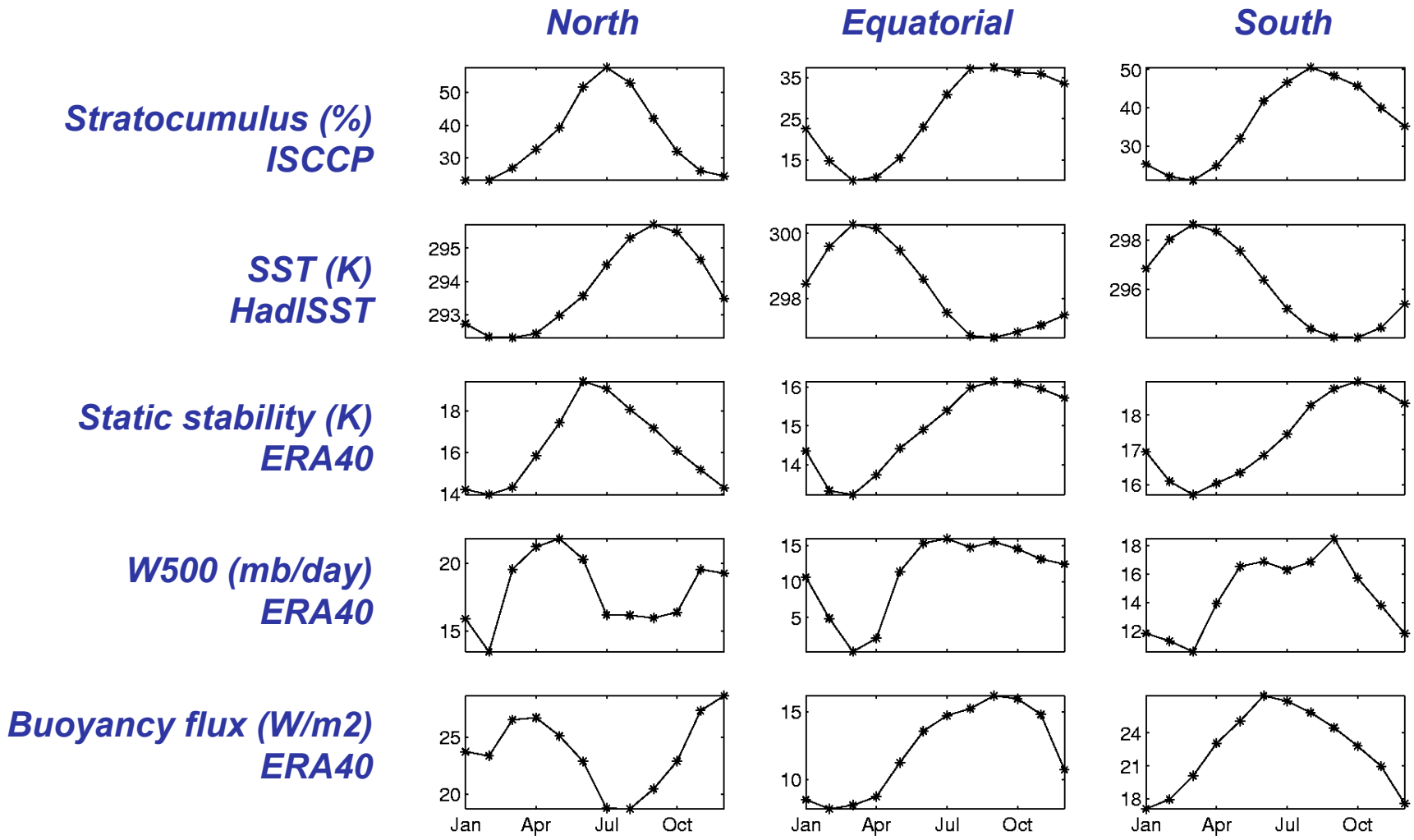
- SWCF: Error up to 30 W/m2 locally.

- when coupling with ocean model: important to produce the correct amount of stratocumulus at the right location

Processes influencing stratocumulus

Annual cycles in observations and reanalysis

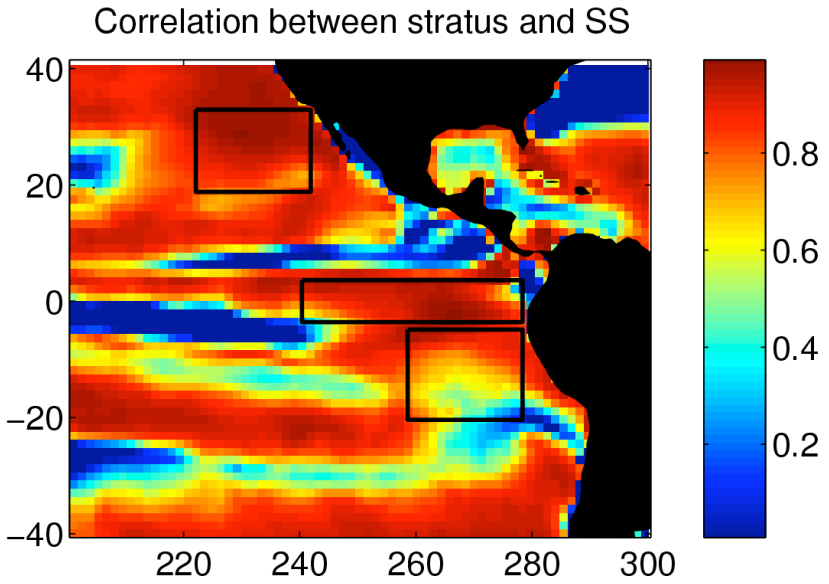
Domain-averaged monthly means



Static stability = consistent predictor of cloud

- Regions follow "Klein Line" (Klein and Hartmann, 1993)
  about 6% increase in cloud per degree of static stability

- Relationship does not hold for smaller domain and timescale averaging

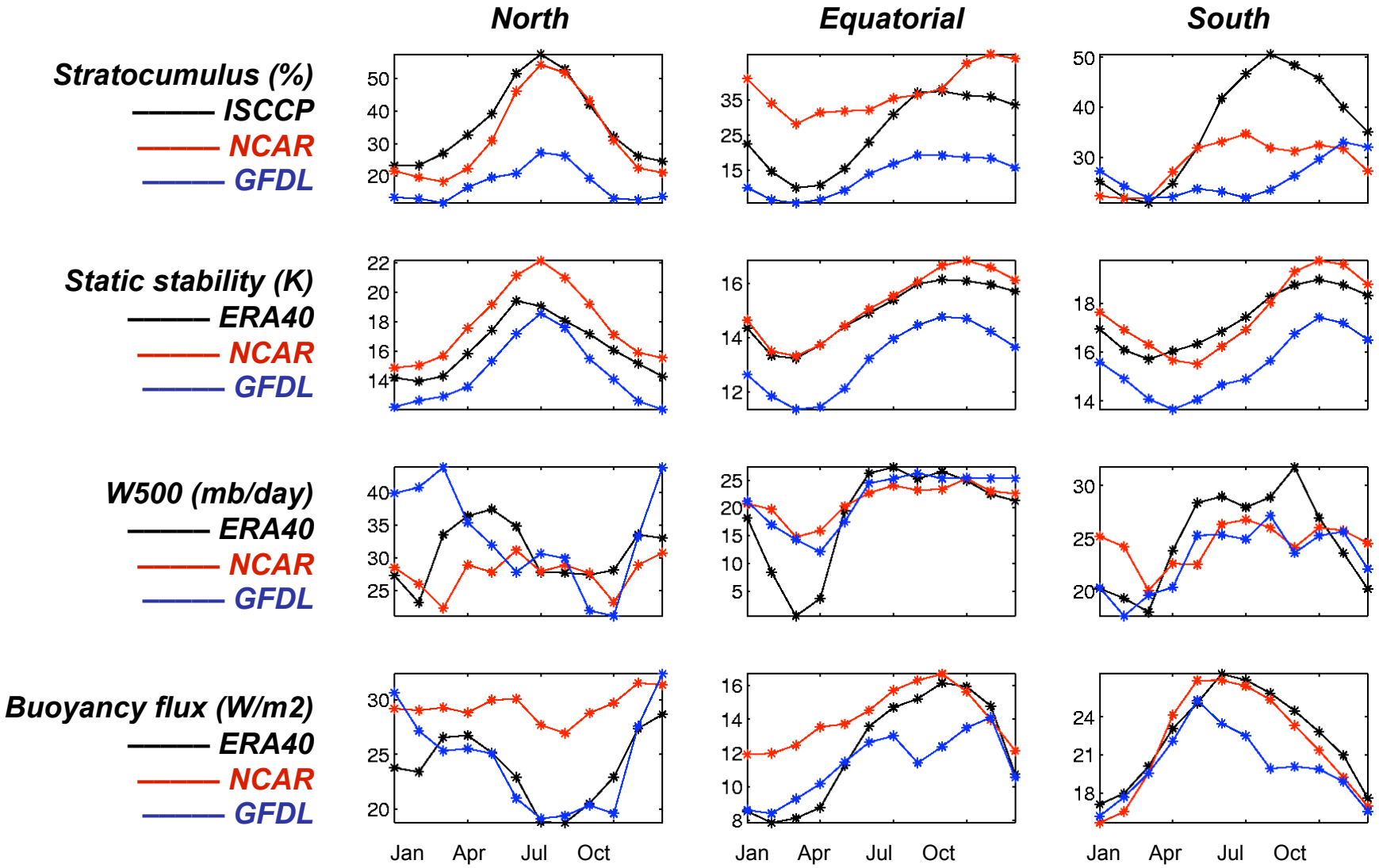


- warmer climate: increase in static stability and therefore in stratocumulus but also changes in other quantities (i.e. subsidence, buoyancy flux)
  => no guarantee that change in stratocumulus will follow Klein Line

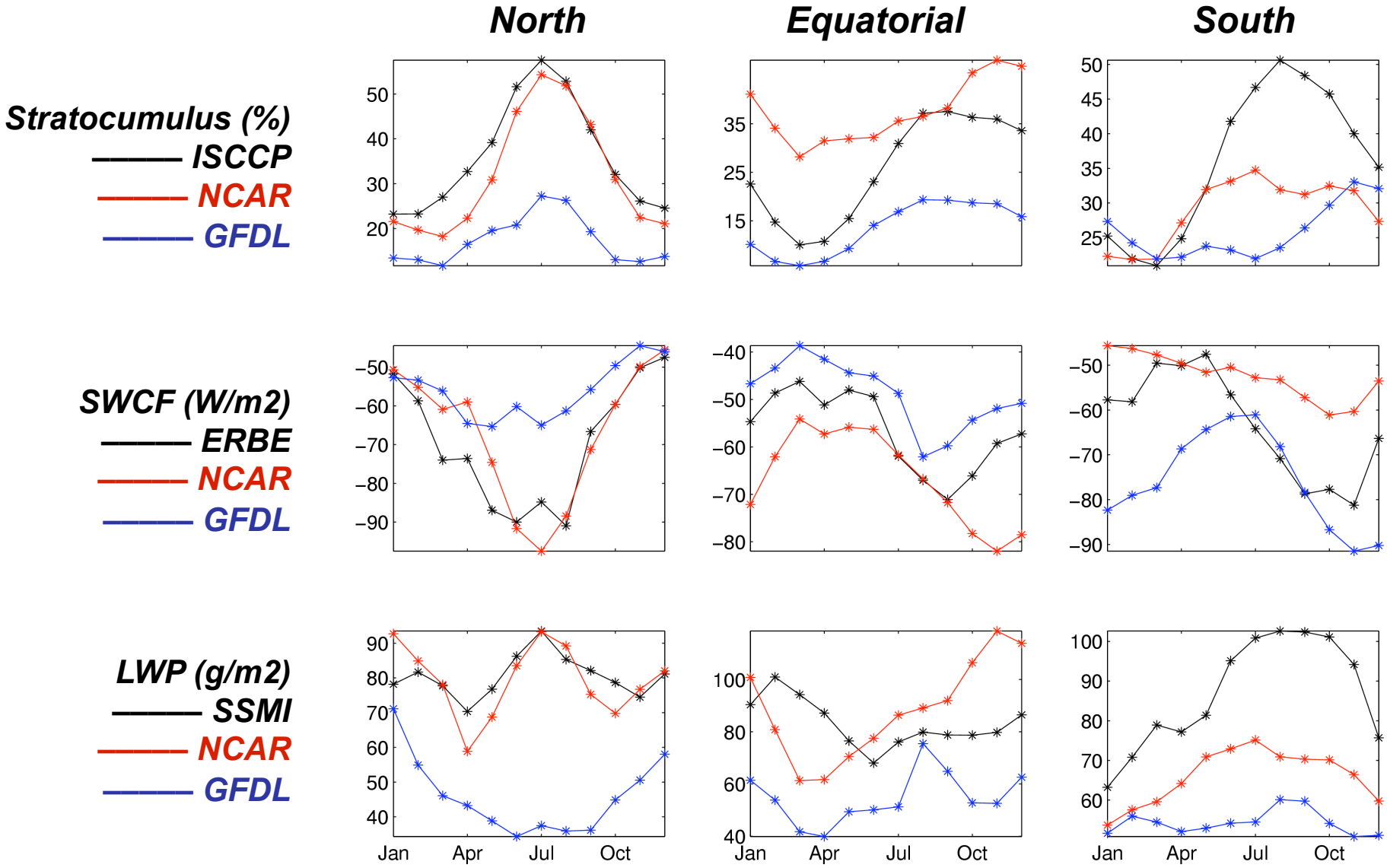
Cloud fraction scheme

- NCAR: diagnostic cloud fraction (empirical “Klein line”)
- GFDL; prognostic cloud fraction (modified Tiedtke, 1993)

GCM results


North
Equatorial
South
Stratocumulus (%)
ISCCP
NCAR
GFDL
Static stability (K)
ERA40
NCAR
GFDL
W500 (mb/day)
ERA40
NCAR
GFDL
Buoyancy flux (W/m2)
ERA40
NCAR
GFDL
Jan
Apr
Jul
Oct

GCM results


North
Equatorial
South
Stratocumulus (%)
ISCCP
NCAR
GFDL
SWCF (W/m2)
ERBE
NCAR
GFDL
LWP (g/m2)
SSMI
NCAR
GFDL
Jan
Apr
Jul
Oct

Conclusion

- Analysis of stratocumulus annual cycle in 3 regions

- The relationships between stratocumulus and other quantities are different in the North from the Equatorial/South regions

- Static stability is the only consistent predictor for the 3 regions
  - However: correlation does not hold at smaller domain or timescale
  - warmer climate: no guarantee that change in stratocumulus will follow Klein Line

- Both models have problems.

At this stage, it is hard to predict which model predicts the change in stratocumulus clouds more accurately.