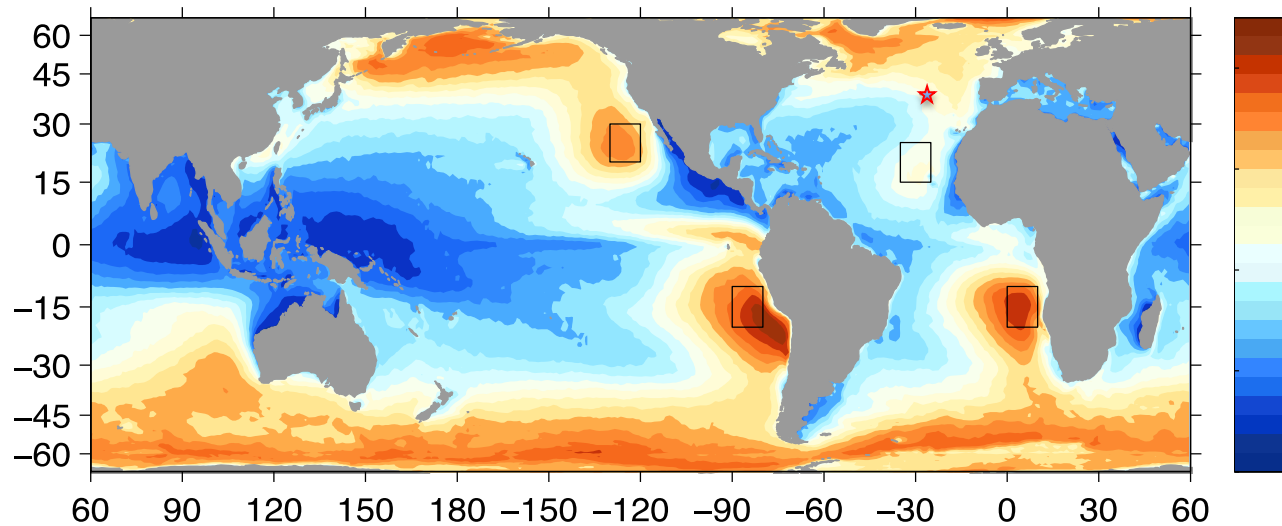


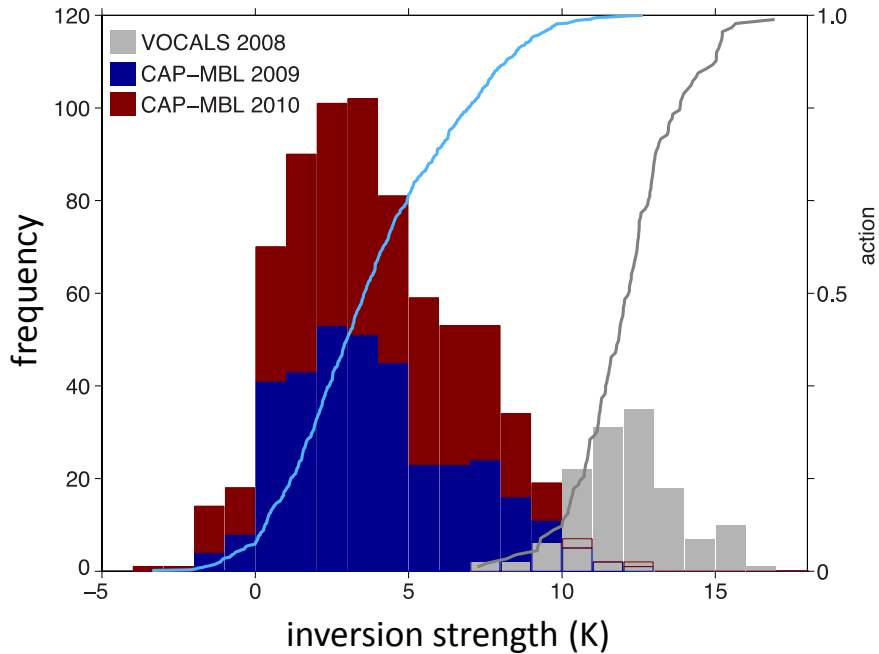
Inversion strength and low clouds: time scales of strat(ocumul)us cloud-top entrainment



Simon de Szoeke, Sandra Yuter, David Mechem

Entrainment Breakout, DOE ASR Meeting 2014

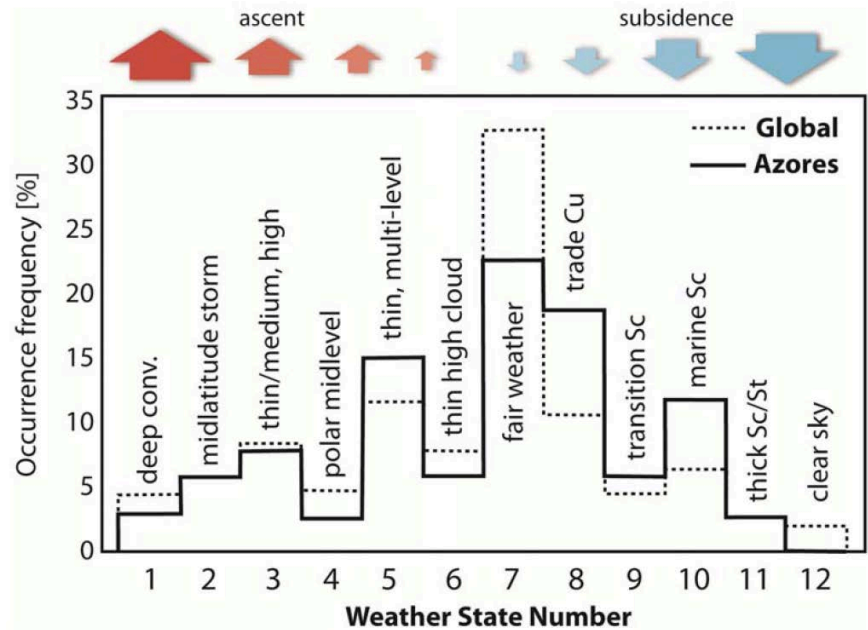
CAP-MBL clouds at Azores



Strong **synoptic variability** of

- inversion strength
- vertical velocity

drives wide cloud variability at the Azores.



reviewed in
Wood et al. 2014, *BAMS*

Tselioudis et al. 2013

Strat(ocumul)us cloud-top entrainment

Klein and Hartmann (1993):

Seasonal-interannual low cloud variations explained by lower tropospheric stability.

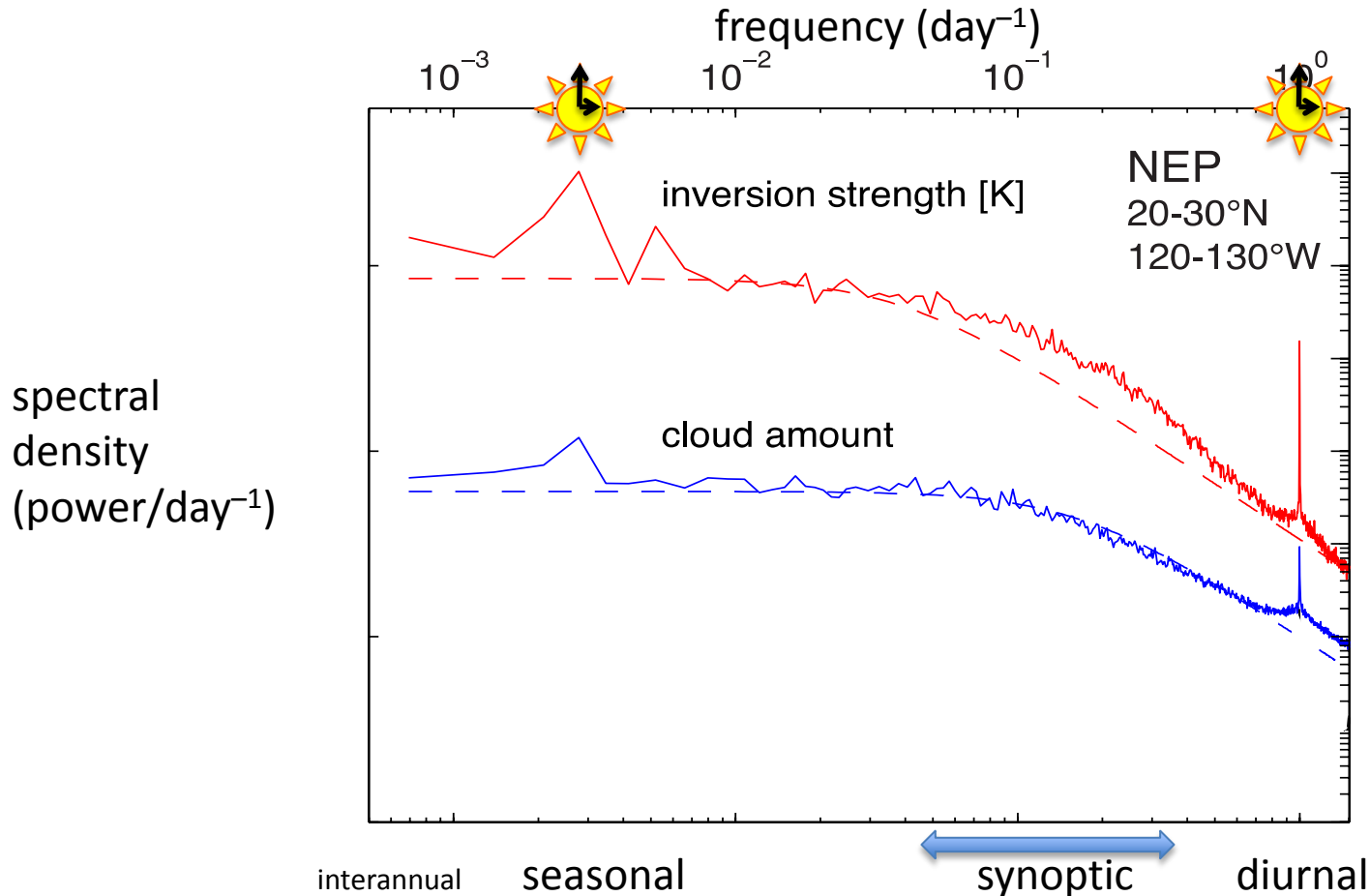
A stronger inversion *limits entrainment* of dry air into the cloud and **increases low cloud fraction.**

Models still use the “Klein line” to determine low cloud or when to use low cloud parameterizations.

Observations

- ISCCP **low cloud** (top $p > 560$ hPa)
 - 27 years, 4x daily, geostationary cloud amount
 - satellite drift regressed out
(Clement et al. 2009, Myers and Norris 2013)
- NCEP reanalysis **inversion strength**
 - Estimated Inversion Strength
(EIS, Wood and Bretherton 2006)

Seasonal, synoptic, diurnal variability in subtropical stratus regions



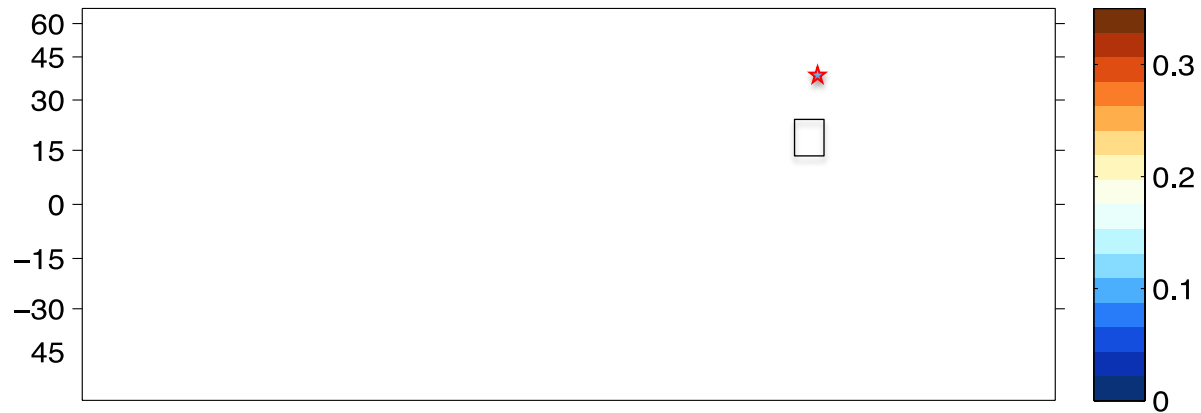
*On what time scales are inversion strength
and clouds related?*

regions of cloud variability

synoptic

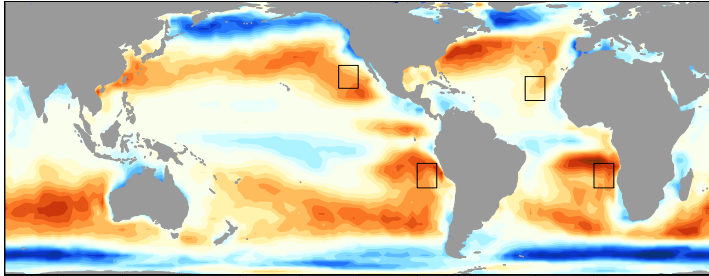


seasonal



low cloud response to inversion strength

total



(more stable)-cloudy

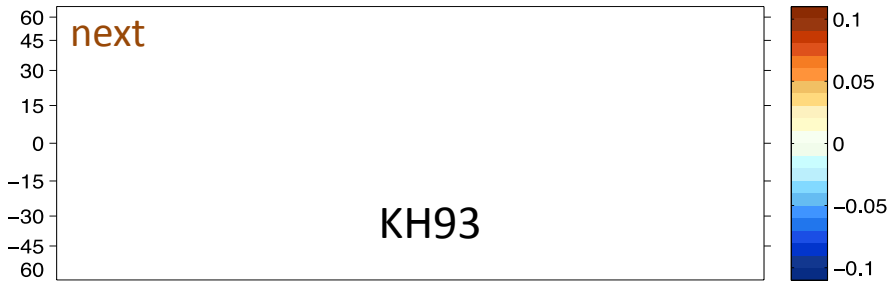
cloud amount per
standard deviation
of inversion strength

(less stable)-cloudy

daily (synoptic)

most

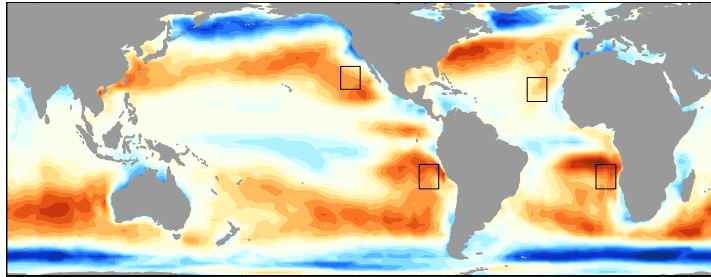
seasonal



- Seasonal covariance dominates in small regions: equatorward of 20° latitude, mostly south of the equator.
- Synoptic cov. dominates poleward of 20° lat.
- Synoptic negative cov. poleward of 45°.

low cloud response to inversion strength

total



(more stable)-cloudy

cloud amount per standard deviation of inversion strength

Interannual and diurnal covariances are 10x weaker!

(less stable)-cloudy

daily (synoptic)

interannual

most

?

?



?

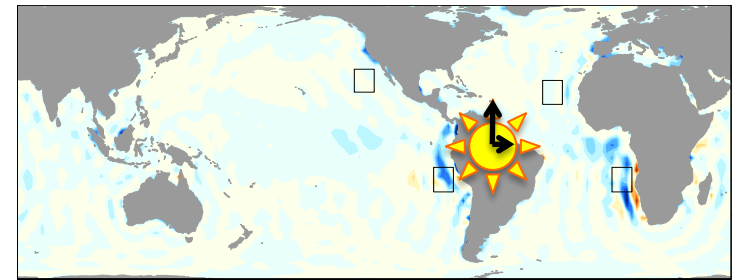
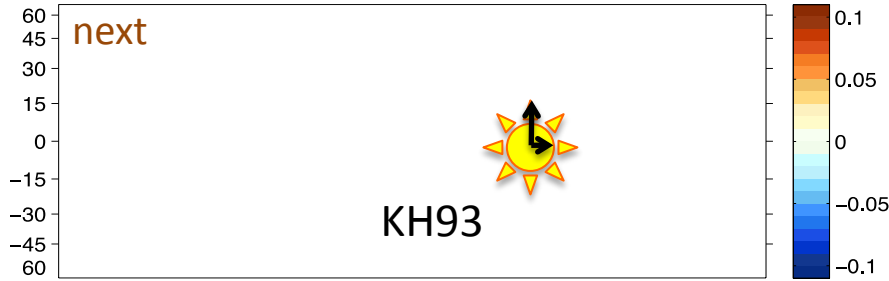
?

?



seasonal

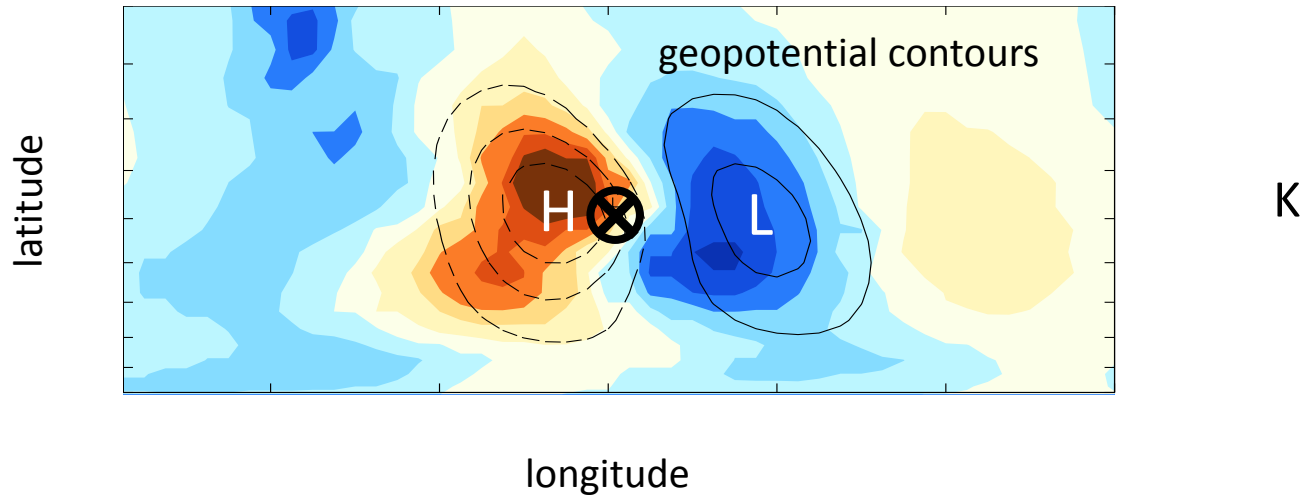
diurnal



Totally different low cloud response to inversion on seasonal vs. diurnal time scale.

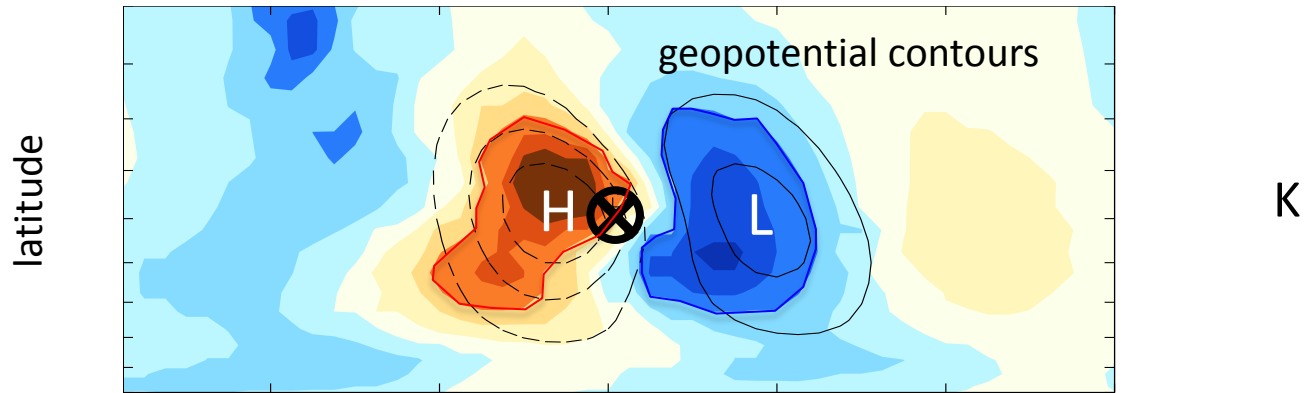
Synoptic pattern regression on downward velocity at \otimes

inversion strength

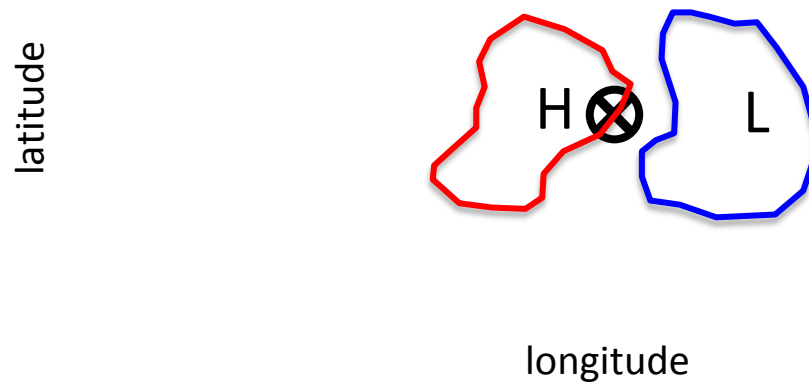


Synoptic pattern regression on downward velocity at \otimes

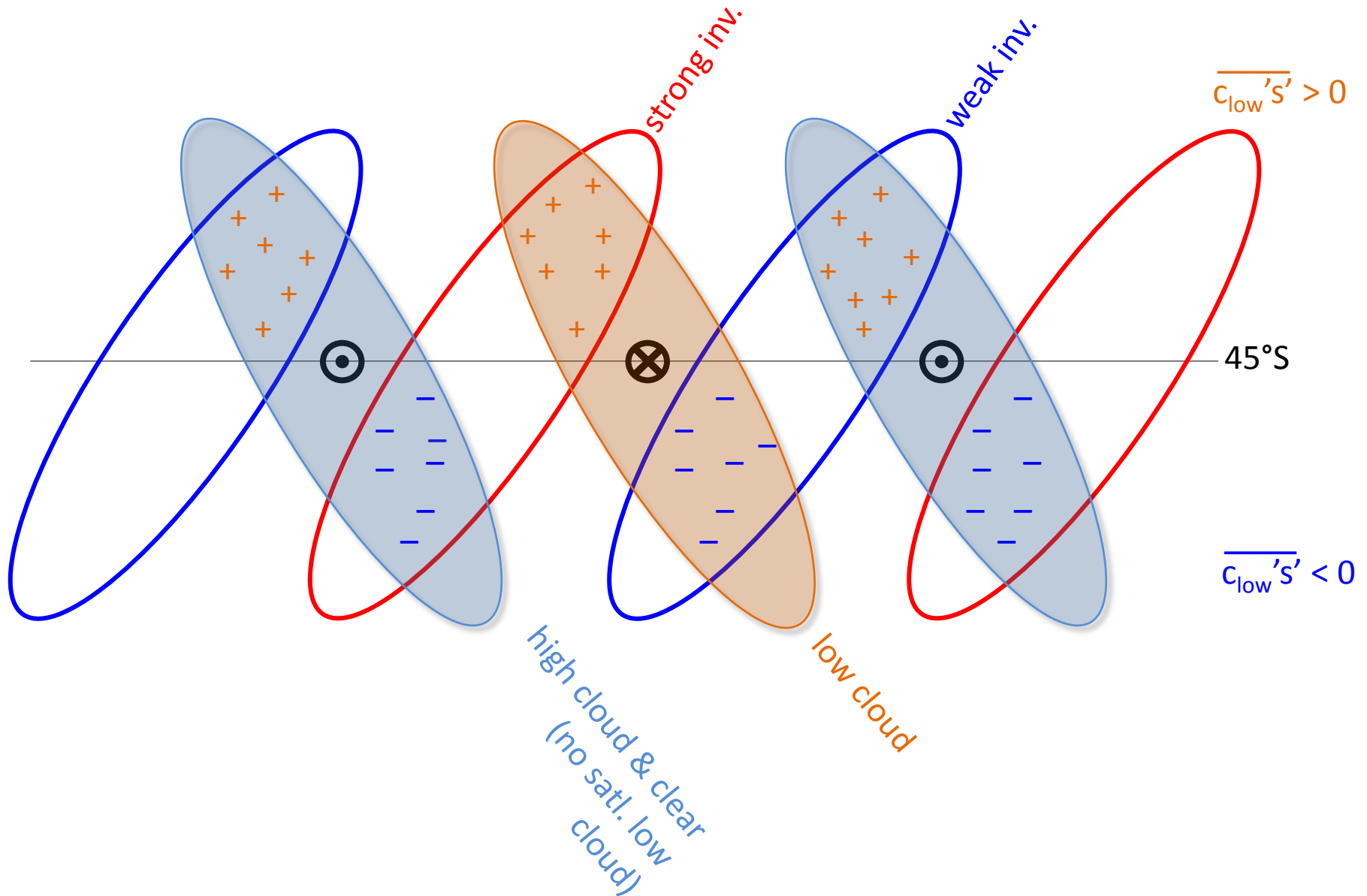
inversion strength



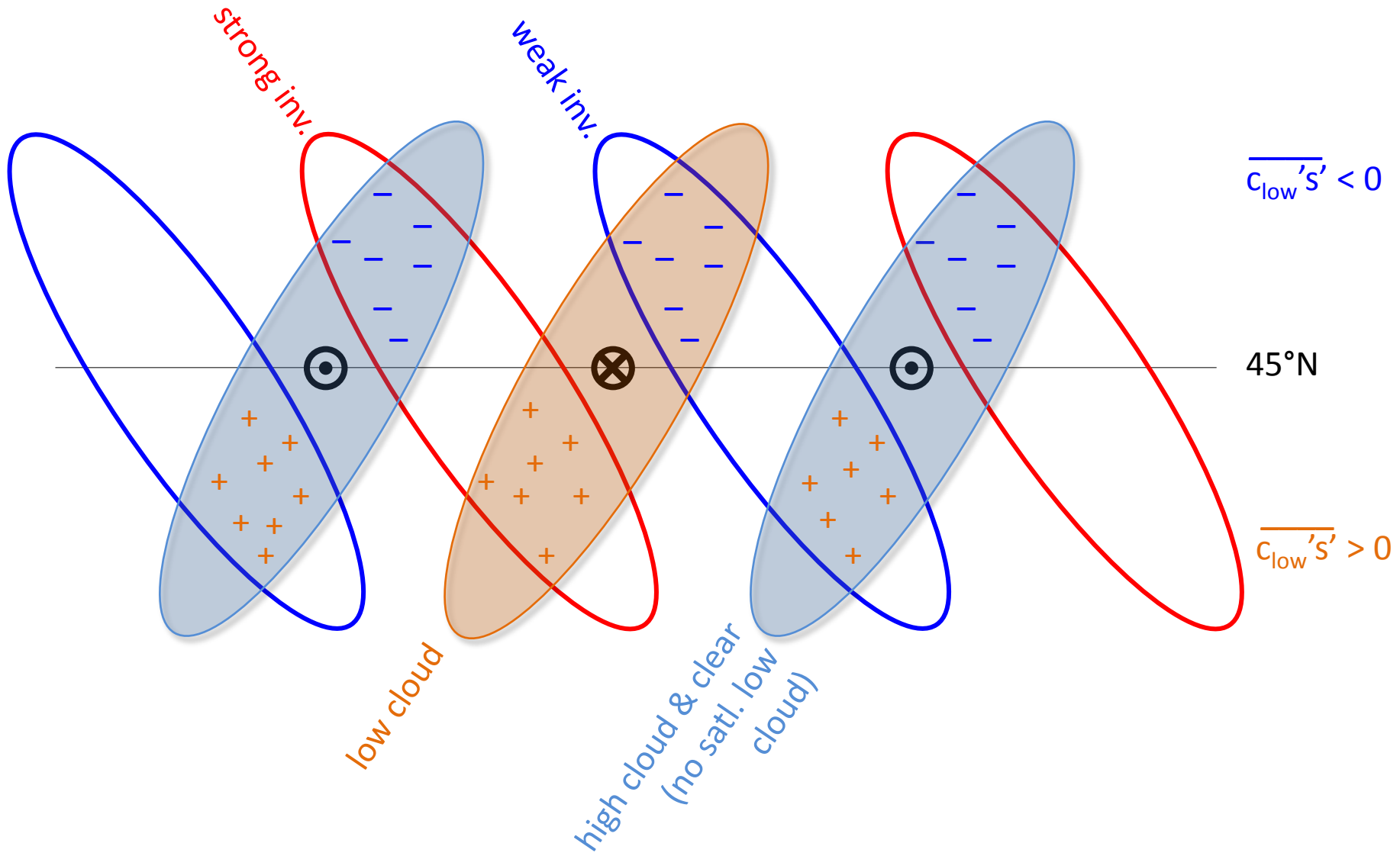
low cloud



southern hemisphere synoptic cloud pattern



northern hemisphere synoptic cloud pattern



Summary

- **Seasonal** low-cloud – inversion strength correlation intact (Klein and Hartmann 1993).
- Stronger **synoptic** correlations, especially in extratropics.
 - Synoptic storm clouds reverse correlation poleward of 45° latitude.
- **Interannual and diurnal** correlations 10x weaker.
- Beware of using “Klein line” to model or evaluate low clouds on time scales other than seasonal.
 - Models need unified cloud-top entrainment parameterizations valid for a wide range of conditions.*