Predicting distributions of TTL Cirrus from thermal and moisture histories

J. Bergman, E. Jensen, L. Pfister, L. Pan, S. Honomichl

Introduction: A good but useless idea

- Created forecast for the occurrence of TTL cirrus for winter 2013 Dryden deployment
- Interesting results but targeting coldest temperatures in the region was more reliable

Do we need parcel histories to forecast clouds?

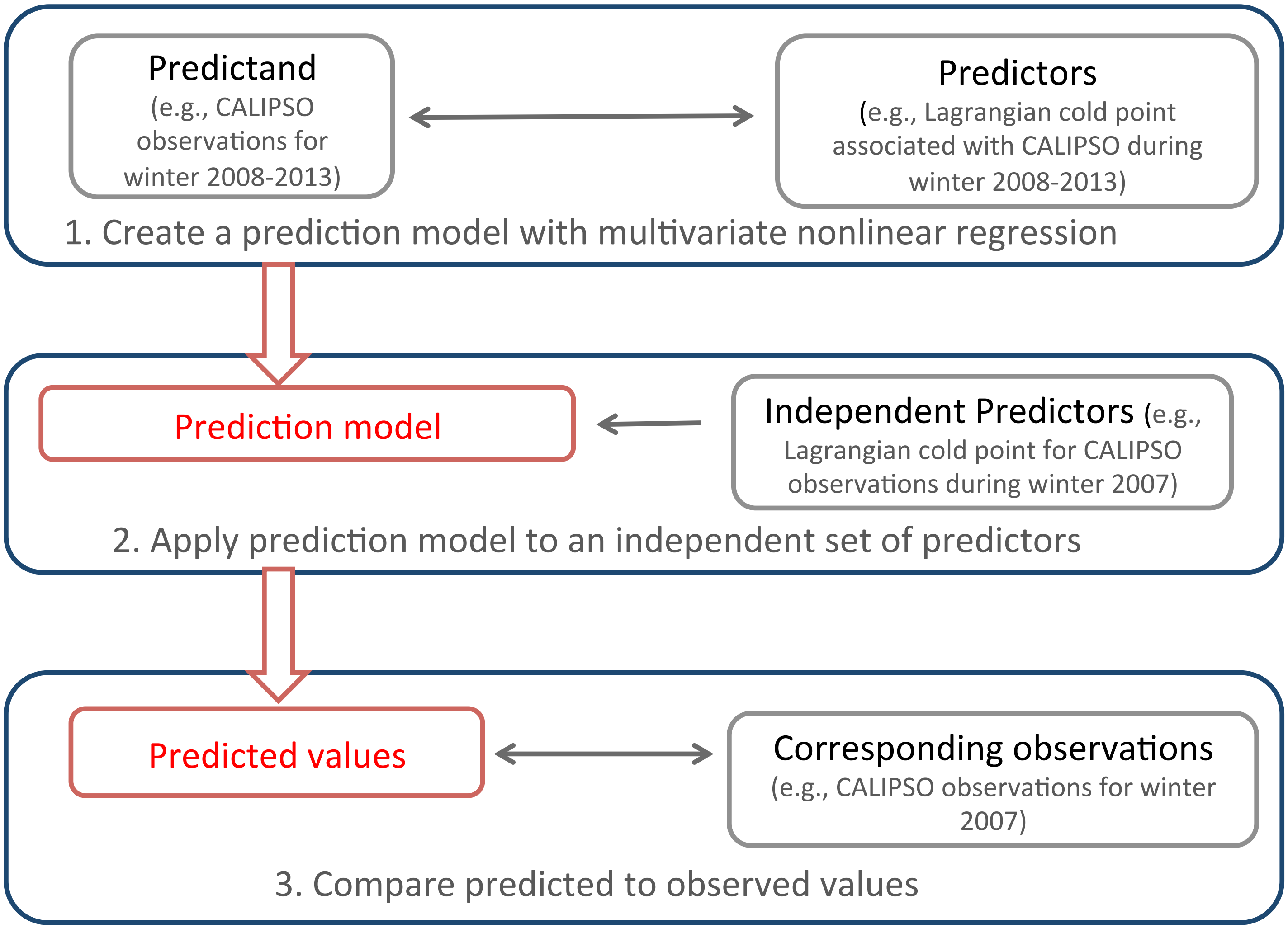
What do cloud fields tell us about dynamical interactions?

Focus on information content

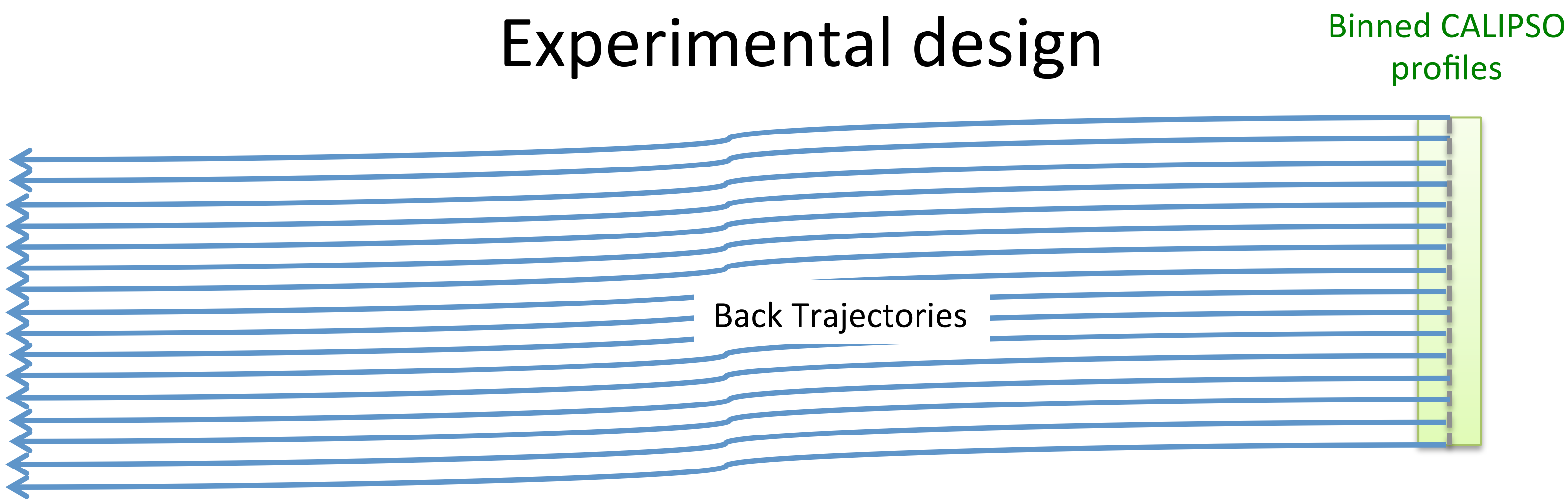
- Predicting cloud occurrence depends on the ‘cloud information content’ of predictors

How much cloud information content is contained in local *v* historical thermal and moisture fields?

We analyze dynamical circulations through predictions of thin cloud distributions near the tropical tropopause



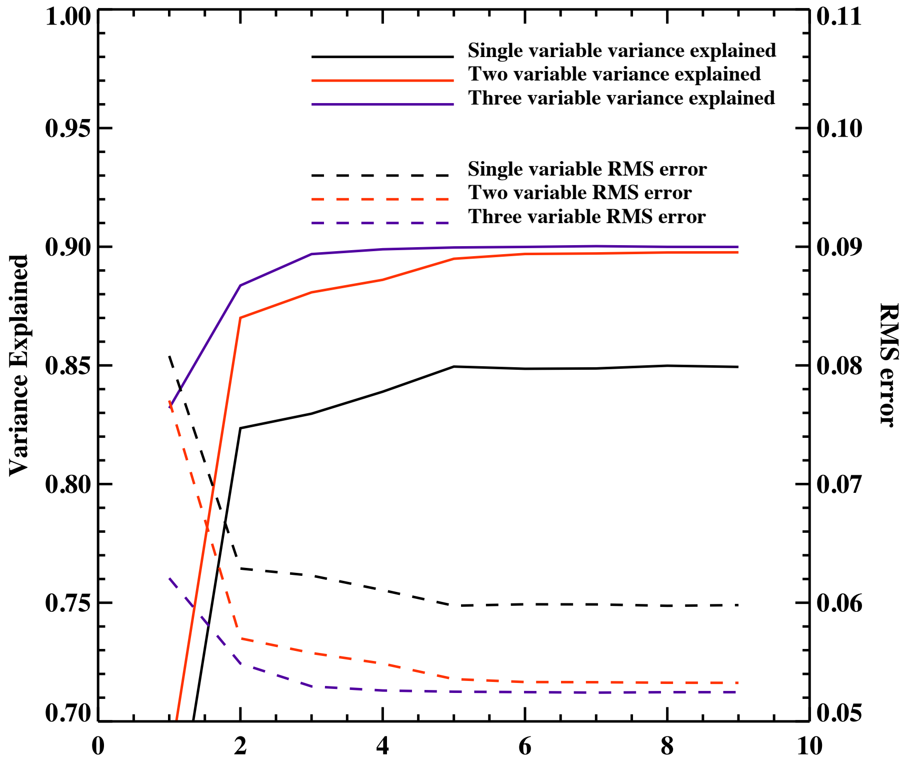
Experimental design



- Calculate TTL cirrus 'probability' from CALIPSO observations
  - 7 winters (J-F for 2007-2013) and 7 summers (J-A for 2006-2012)
  - Look for thin clouds in the height range: Δz = 15.2-17 km (~100-125 mb)
  - Combine observations into 2° x 2° x 6 hr bins
  - Thin clouds have $\tau \leq 0.3$
  - Probability = # of CALIPSO profiles with thin clouds in Δz /# of profiles
- Run 20 (30 d) back trajectories from each bin center – evenly spaced in altitude
- Use 4 predictors: T_0, q_{v0}, $\delta T = T_0 - T_{min}$, $\delta q = q_{v\ min} / q_{0\ sat}$
- Gather layer-average statistics for prediction model

The method is stable out to 9 orders
Meaningful values are obtained within ~6 orders

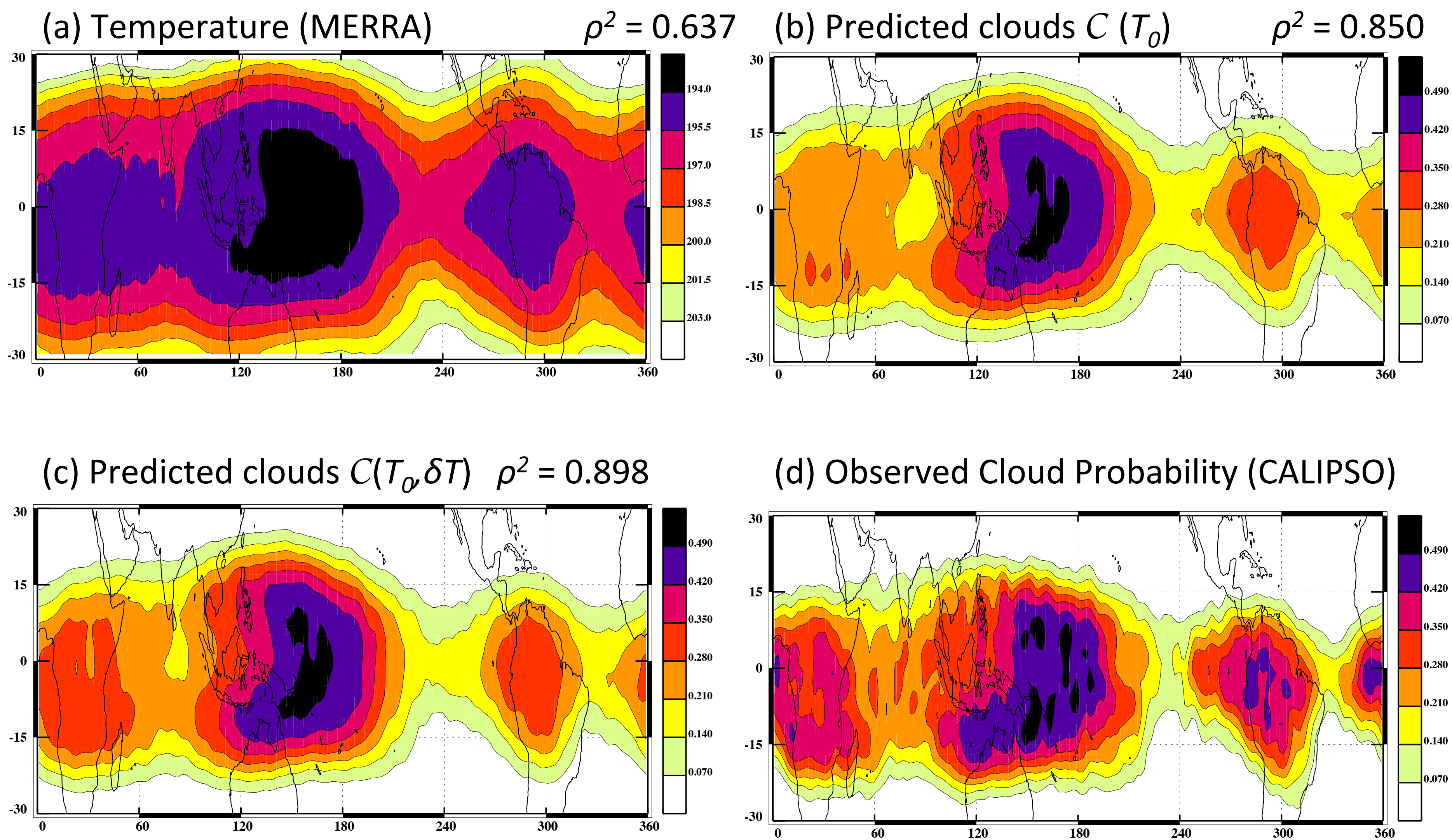
RMS error; Explained variance
v. Regression order



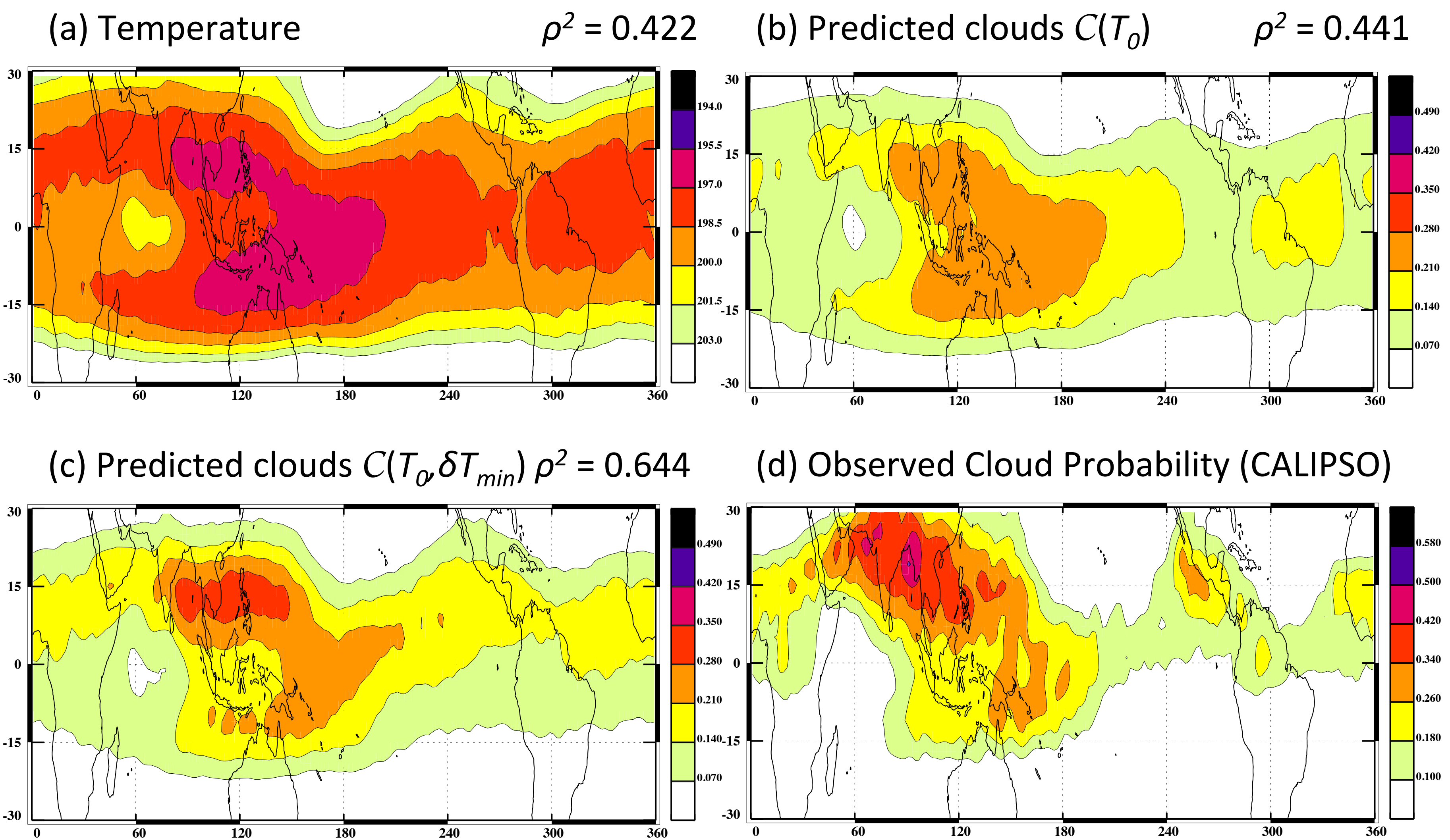
Regression Order

Uses
local temperature
Lagrangian cold point differential
Lagrangian dry point differential

For winter, the nonlinear dependence of clouds on temperature is important

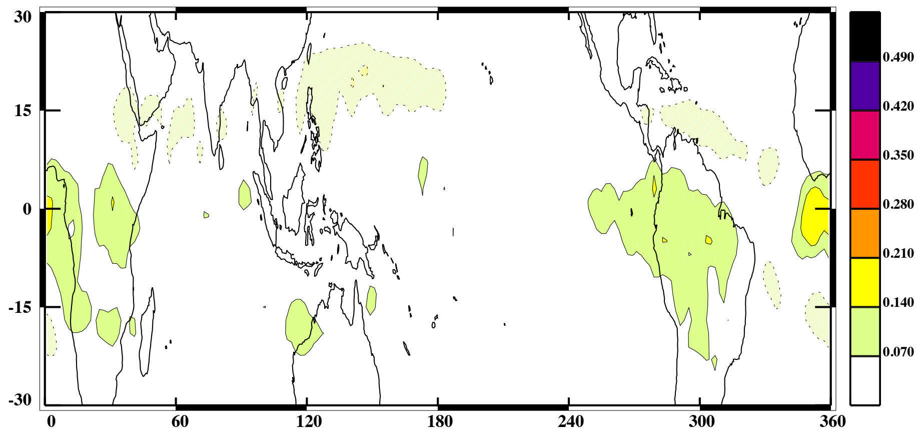


For summer distributions the Lagrangian cold point is important



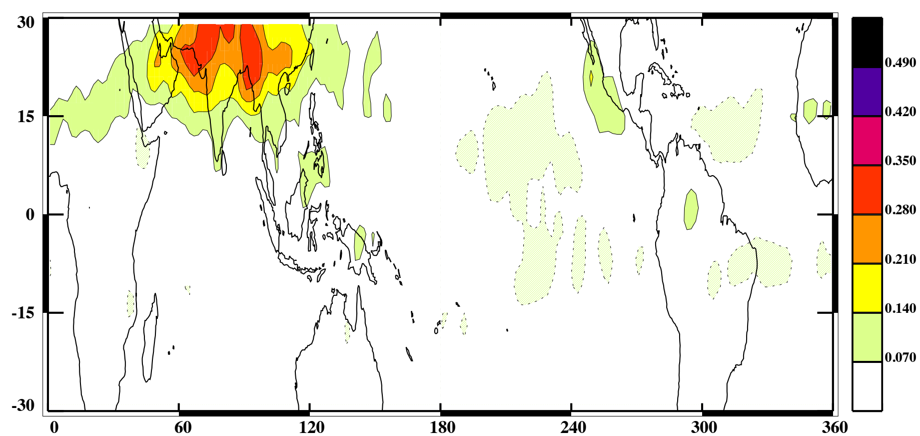
Cloud prediction errors C-$C(T_0, \delta T_{min})$

Winter



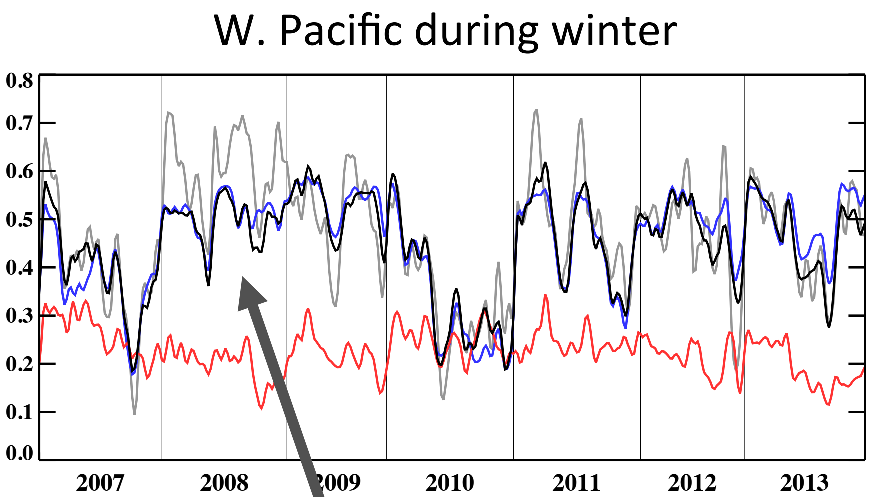
Tropical E. Atlantic stands out as anomalous

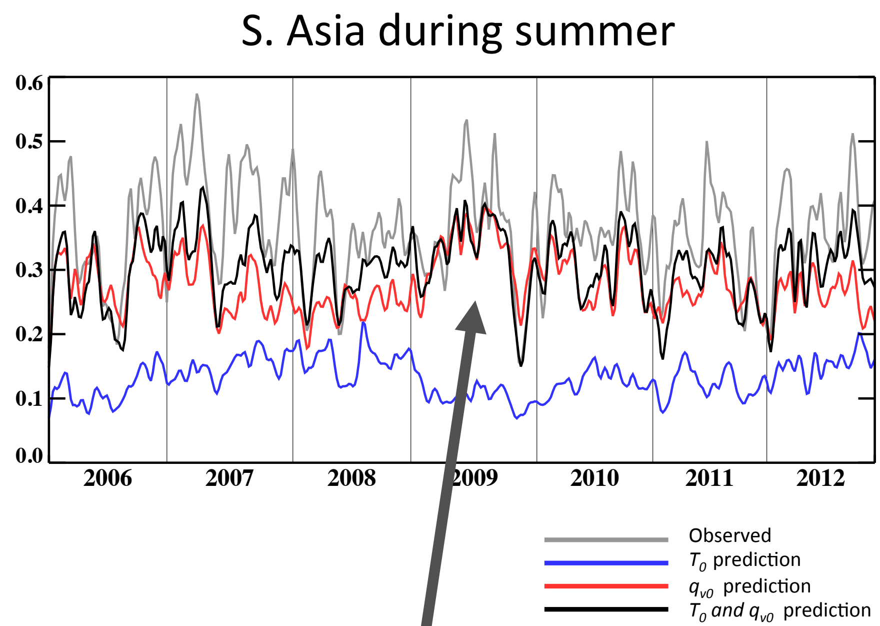
Summer



Asian monsoon region stands out as anomalous

The dynamics involved with the formation of TTL cirrus in the west Pacific and southern Asia are fundamentally different





Temperature dominated cloud formation

Moisture dominated cloud formation

Conclusions

- Local fields – particularly relative humidity - are good predictors of thin cirrus distributions near the tropical tropopause
  - As they should be
- Lagrangian cold and dry points are also good predictors
  - There is shared information among local and historical fields
- The relative information content within different fields can be analyzed to reveal important dynamical interactions