New Climate Divisions for Monitoring and Predicting Climate in the U.S.

Klaus Wolter and David Allured
NOAA-ESRL, Physical Science Division, and CIRES Climate Diagnostics Center; University of Colorado at Boulder
klaus.wolter@noaa.gov

- **Motivation (keeping track of & predicting climate anomalies)**
- **Methodology (blend of two (three) multivariate techniques)**
- **National Results**
- **Summary and Outlook**

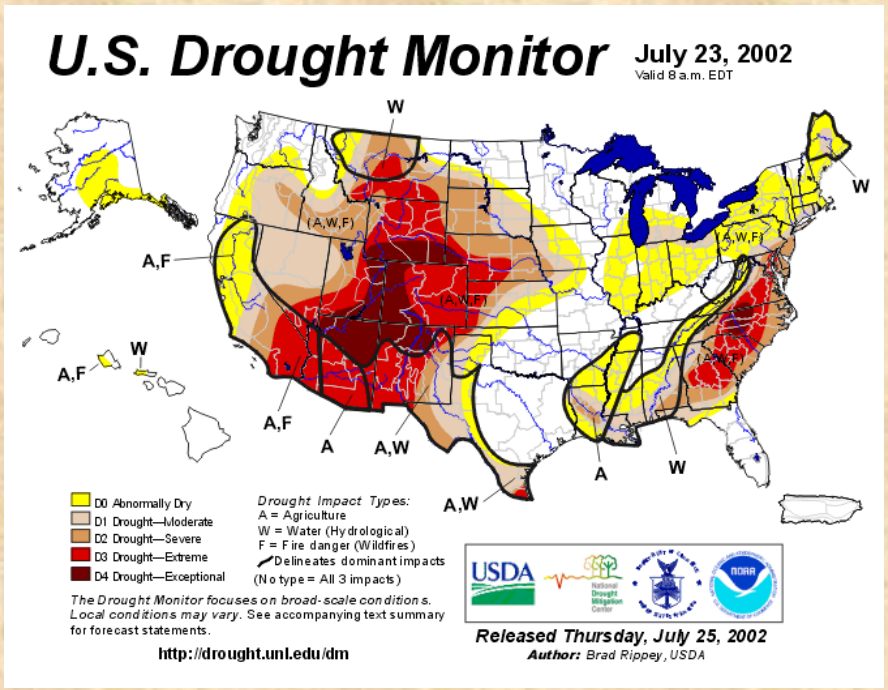
Western Water Assessment

NOAA-CIRES Climate Diagnostics Center

Colorado University of Colorado at Boulder

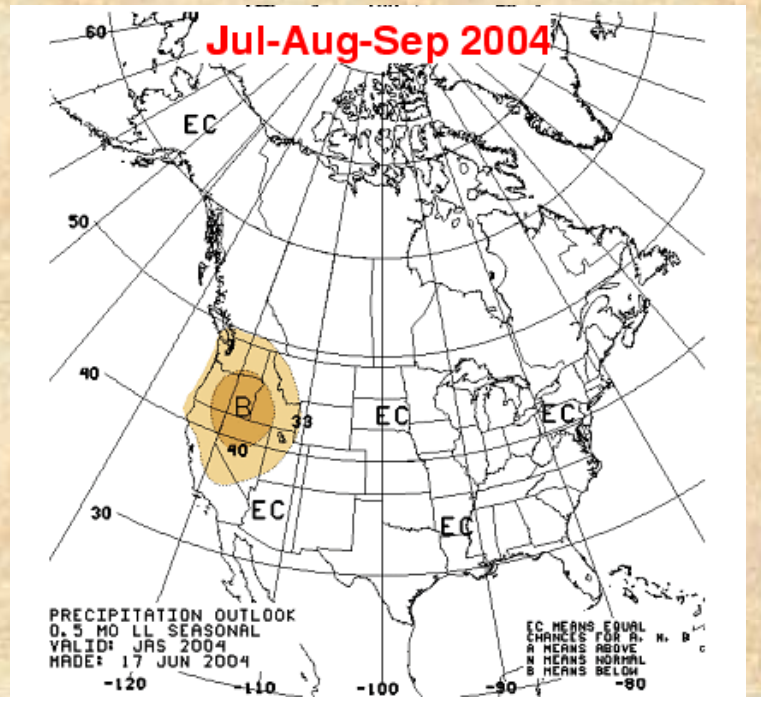
NOAA

Near-real time monitoring and climate predictions are often based on Climate Divisions



A large fraction of the information incorporated into the U.S. Drought Monitor is based on preliminary climate division averages, often ignoring SNOTEL data. This has made drought monitoring more difficult in the West.

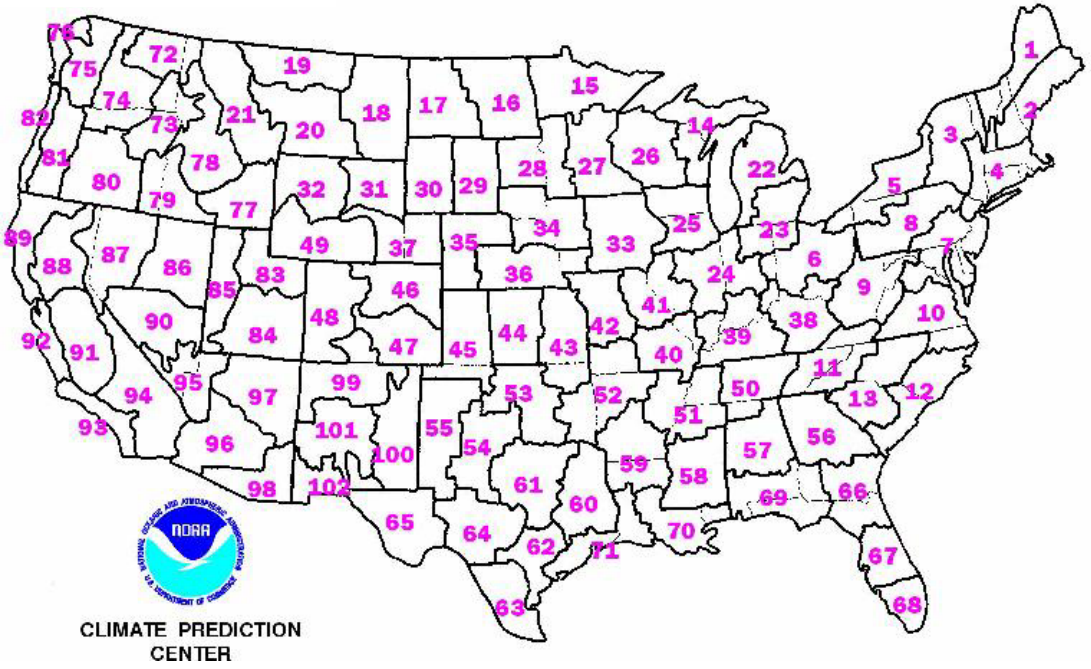
CPC uses mega-divisions as predictands and for verification. Due to sub-optimal signal-to-ratios, this approach may have yielded forecasts that do not fully capture the predictive signal, even from extreme ENSO phase composites.



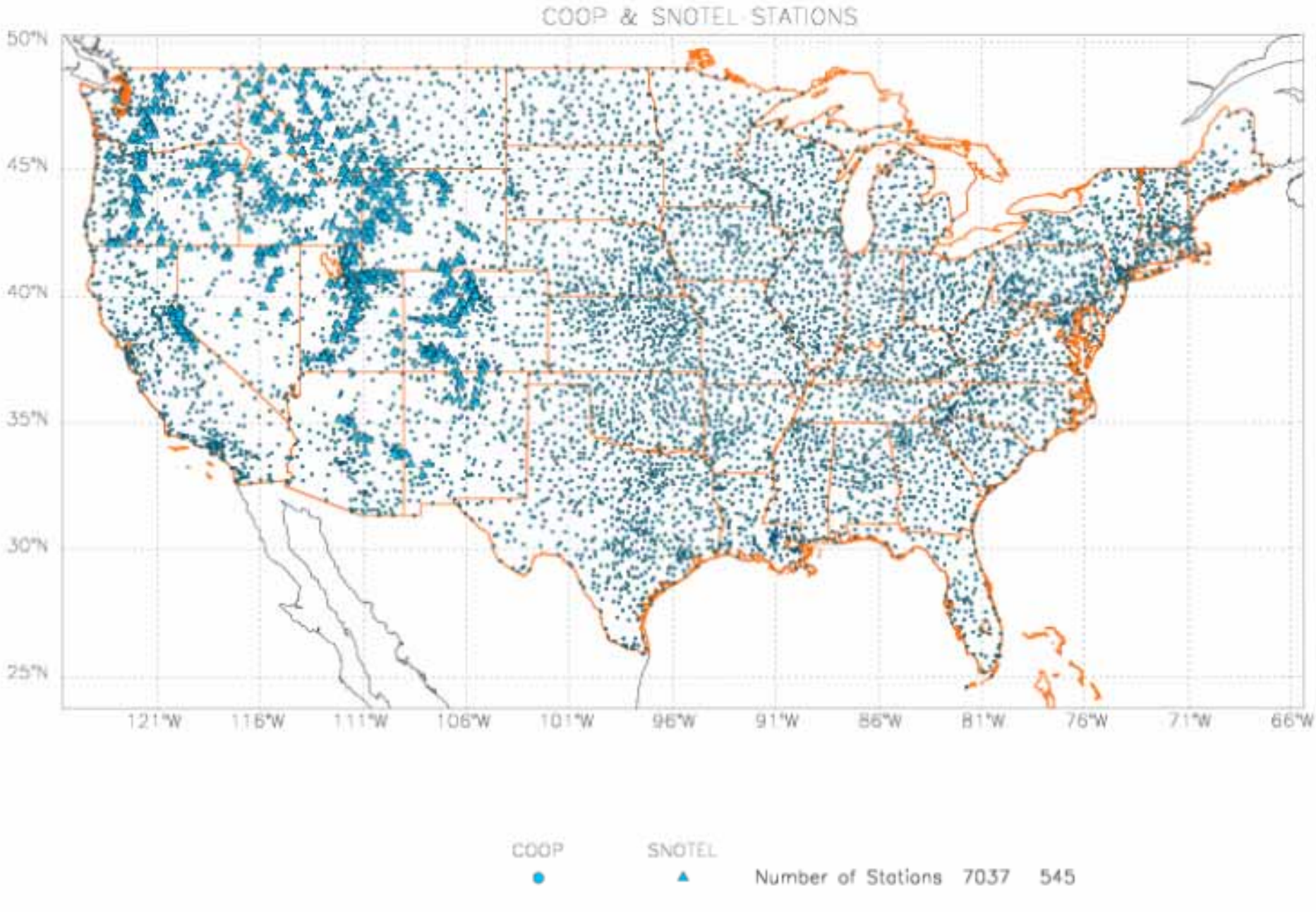
Traditional Climate Divisions cover U.S. unevenly

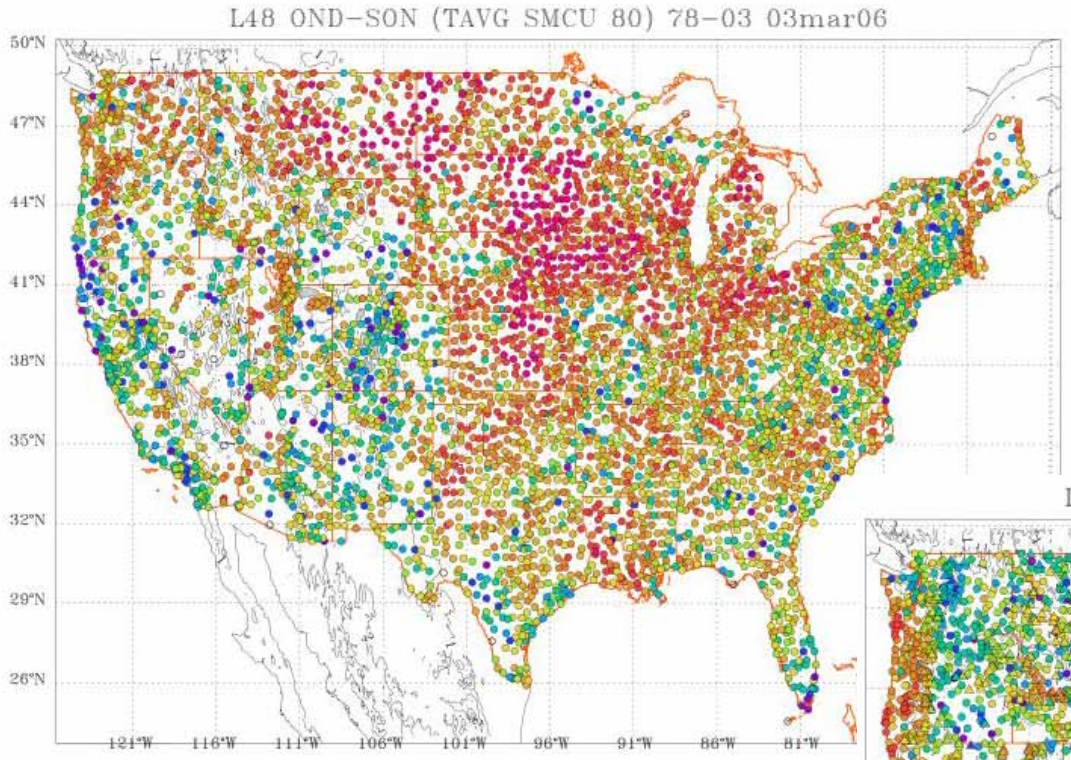
This is a map of 344 NCDC climate divisions currently in use over the U.S. Note the changing size as one goes from east to west, as well as from one state to another.

CPC uses 102 mega- or forecast divisions in their forecasts. The divisions in the West closely correspond to NCDC climate divisions. This approach is more even-handed, but still hampered by being constrained by CDs and state boundaries.

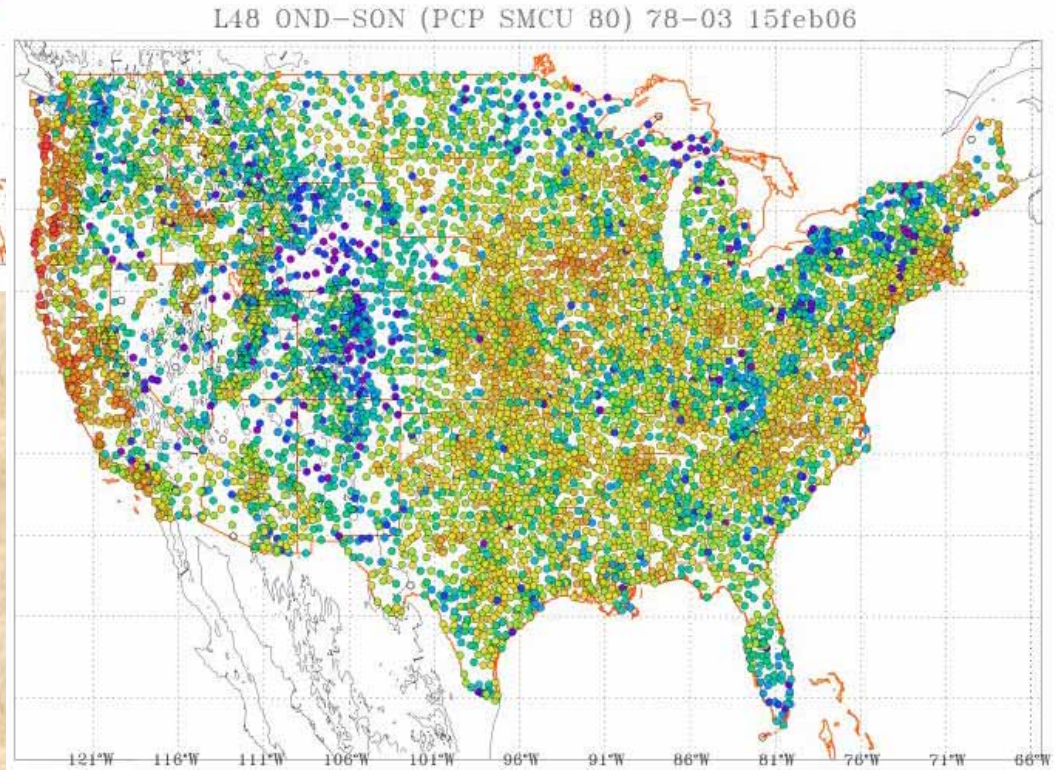


Precipitation Station Distribution (WY'79-'02)

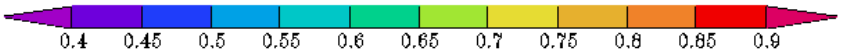




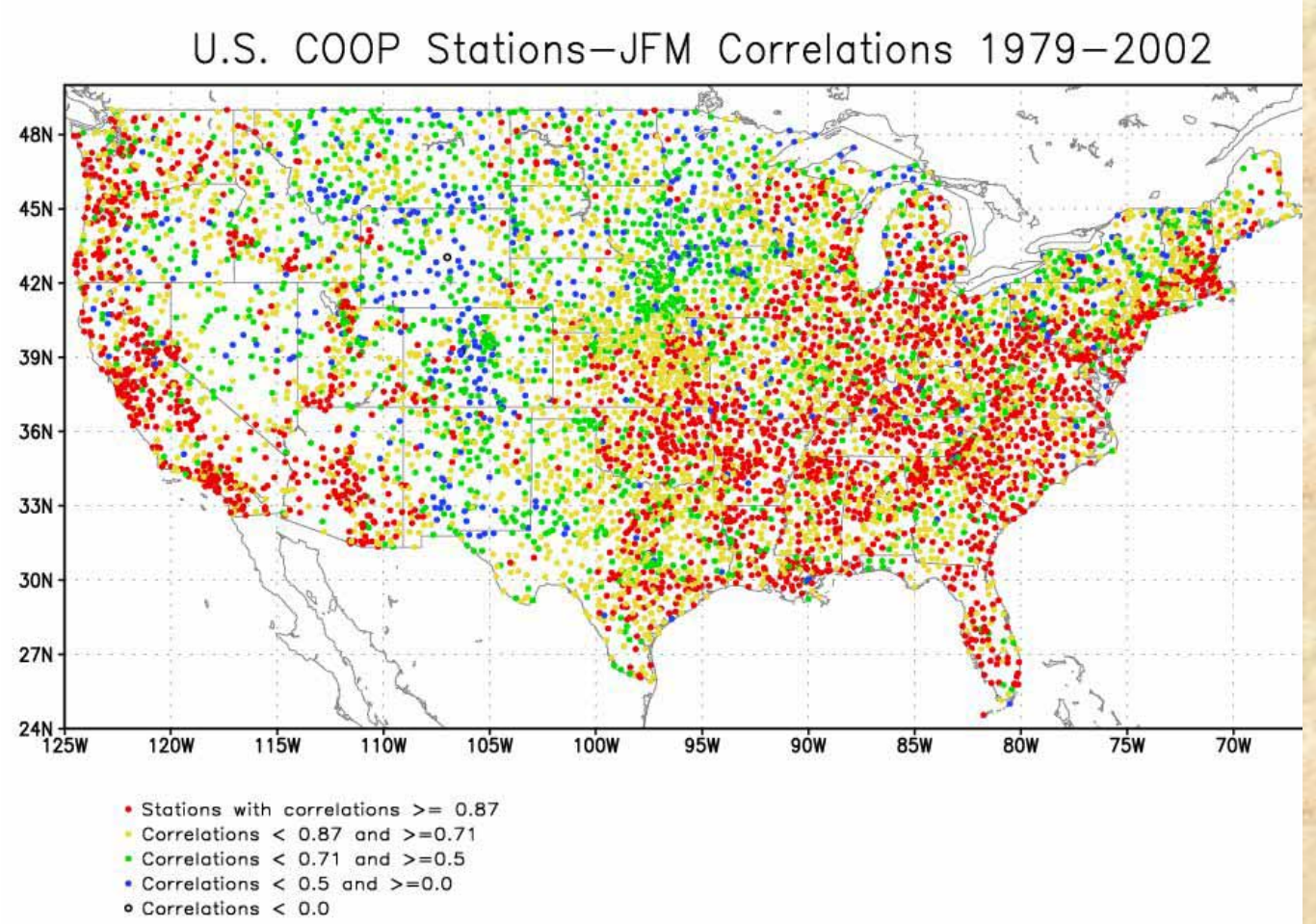
<r>(80km) - all seasons, for temperature (left) and precipitation (bottom)

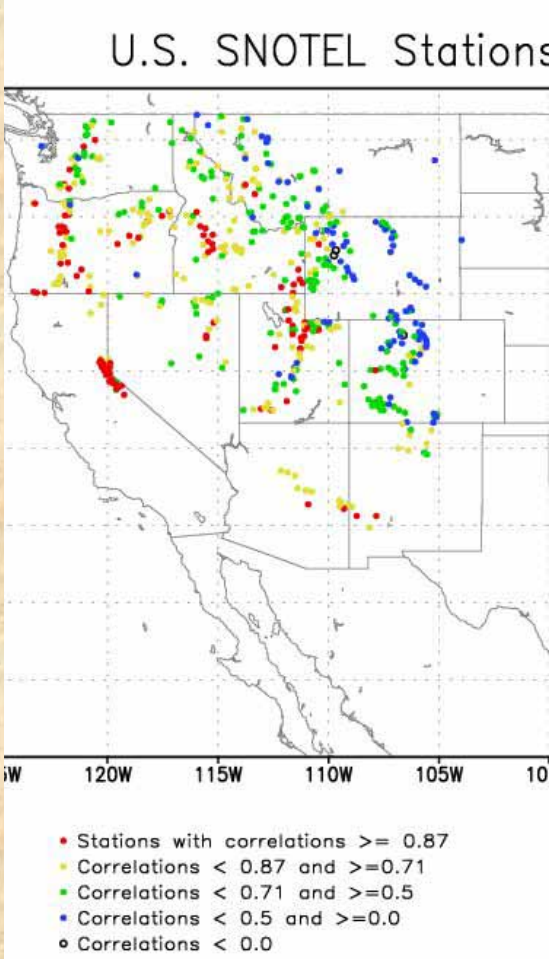


Correlativity tends to be higher for temperatures (top) than for precipitation (right) - except for CA+). Interior West contains biggest trouble spots.



Fidelity of Climate Divisions (COOP vs. SNOTEL)



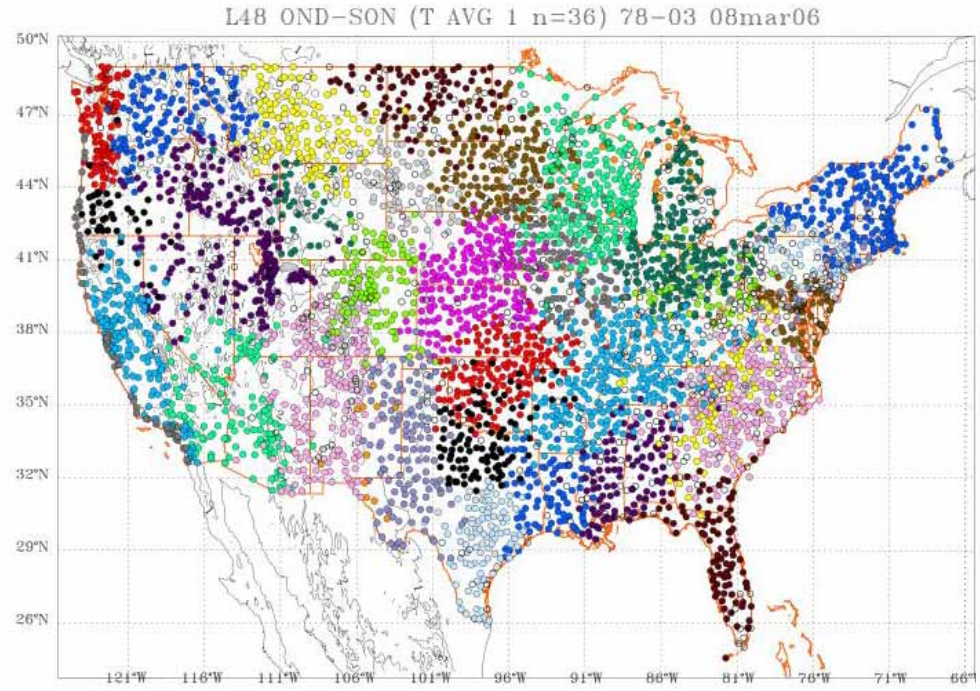


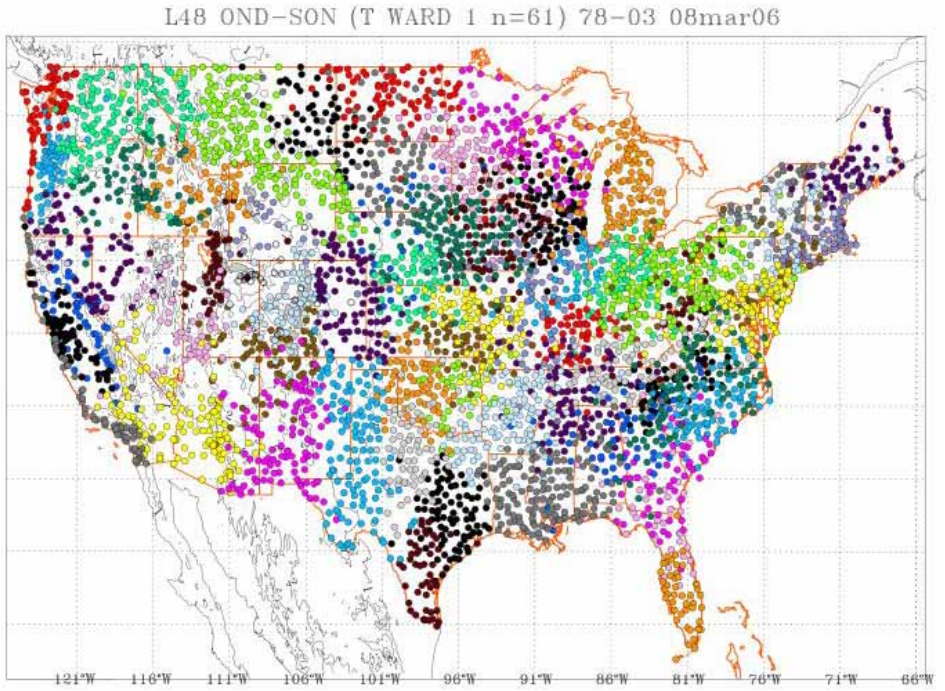
Seasonal correlations between CDs and COOP stations during Jan-Mar 1979-2002 (precip) - this is one of the best seasons for climate division representativeness (summer is the worst), as well as one of the best predicted seasons in the U.S. **Green and blue dots show that divisional indices carry less than 50% of the local seasonal precipitation variance in the Great Basin, along the Rocky Mountain Front Range, and even in the Midwest.**

Creating new Climate Divisions based on 2nd moment statistics (Climate Services Support)

- **Multivariate statistical approaches:** two types of cluster- (Average Linkage and Ward) plus Rotated Principal Component (RPCA) analyses, based on linear correlation matrix of sliding seasons;
- Originally divided the U.S. into **10 subdomains** - RPCA would not yield sufficient number of regions, if applied nationally; however, RPCA did not appreciably improve product, so we could switch to national cluster analyses without RPCA.
- In order to optimize usage of SNOTEL data, the analyses were conducted for **WY 1979-2003.**

Temperature “Average” and “Ward” clusters

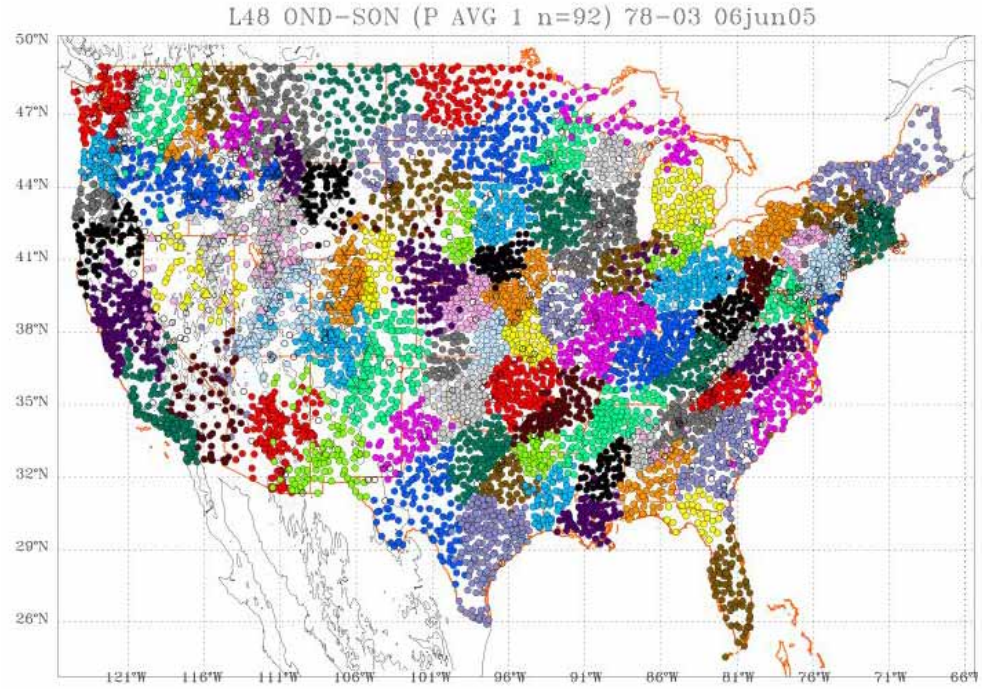


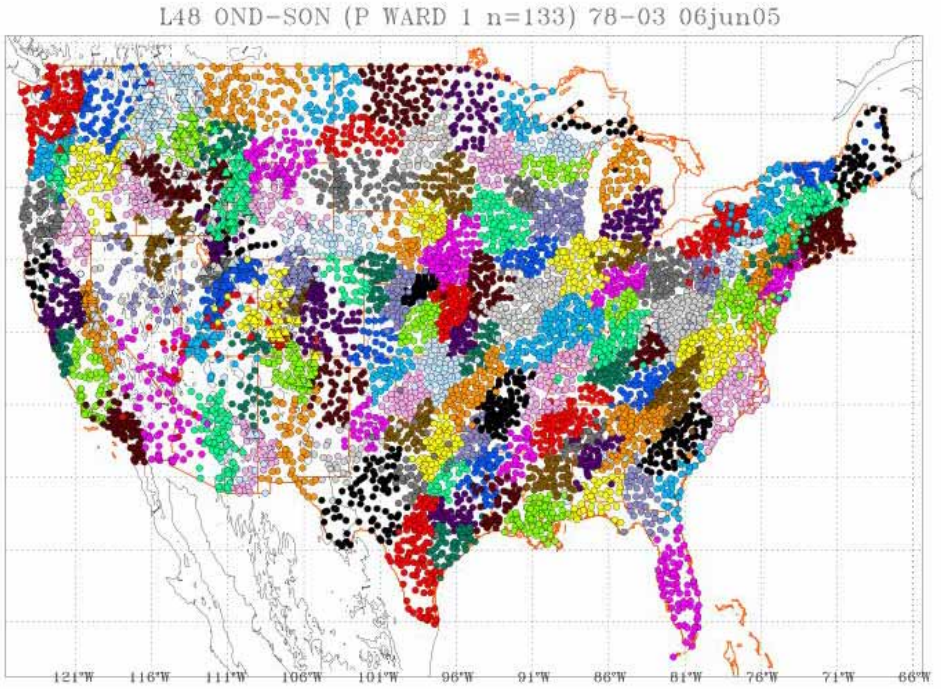


(1)High station-to-station correlations yield large, interlaced clusters; SNOTEL not used due to QC.

(2)Pacific coastal zone is one example where existing CD’s actually match statistical associations.

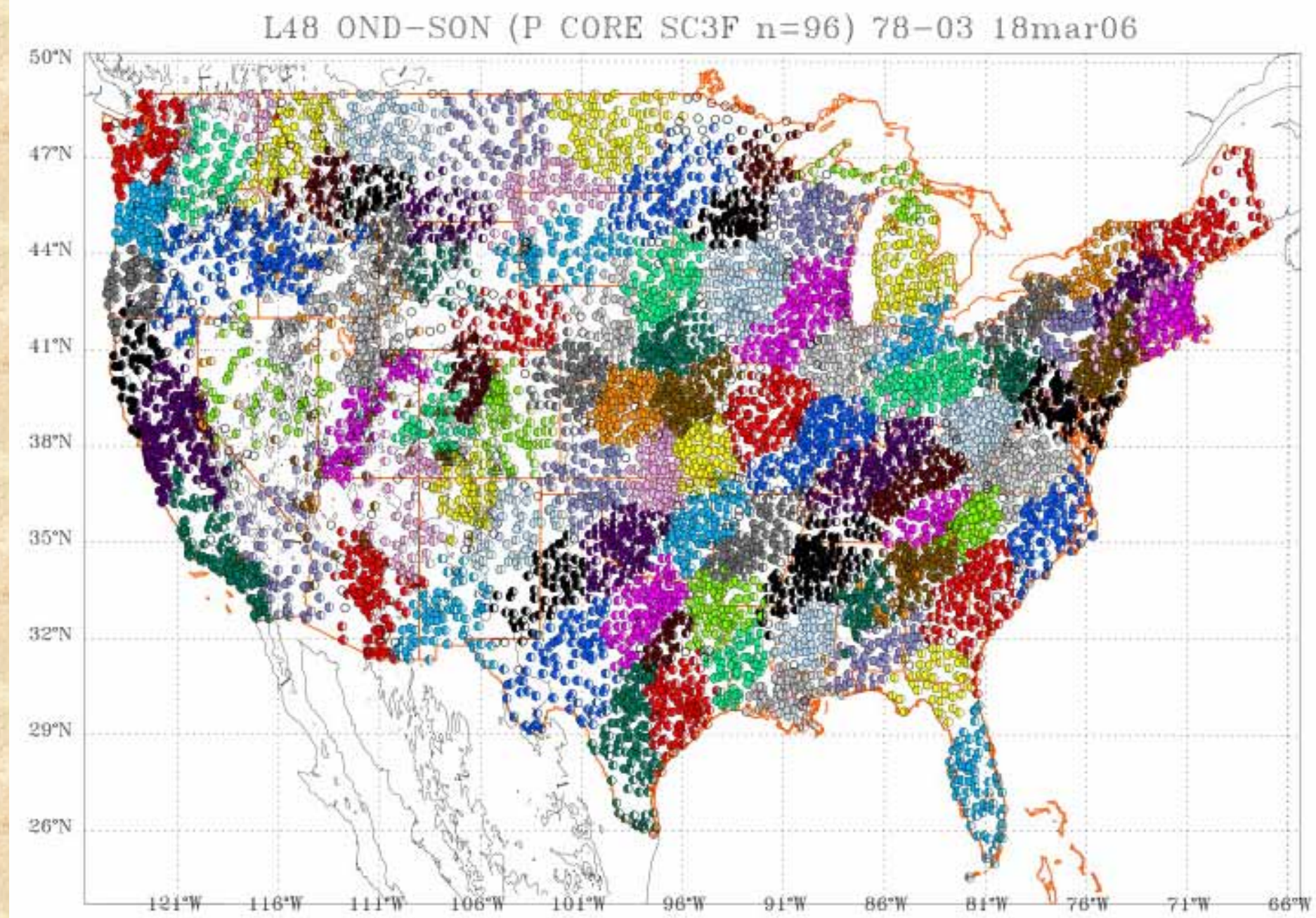
Precipitation “Average” and “Ward” clusters



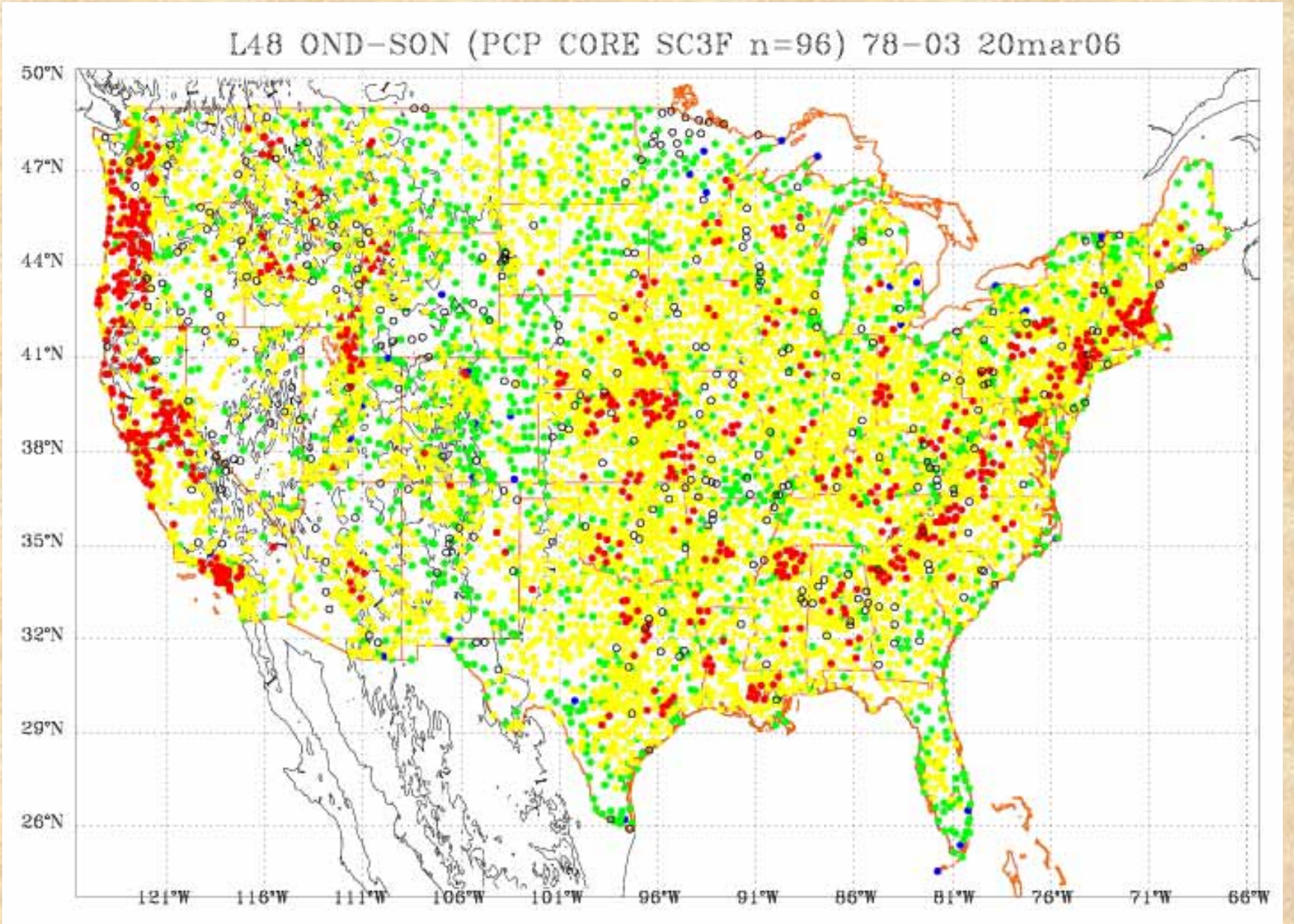


Precipitation clusters tend to be more compact and organized via typical storm tracks (southeast), and/or topography (west).

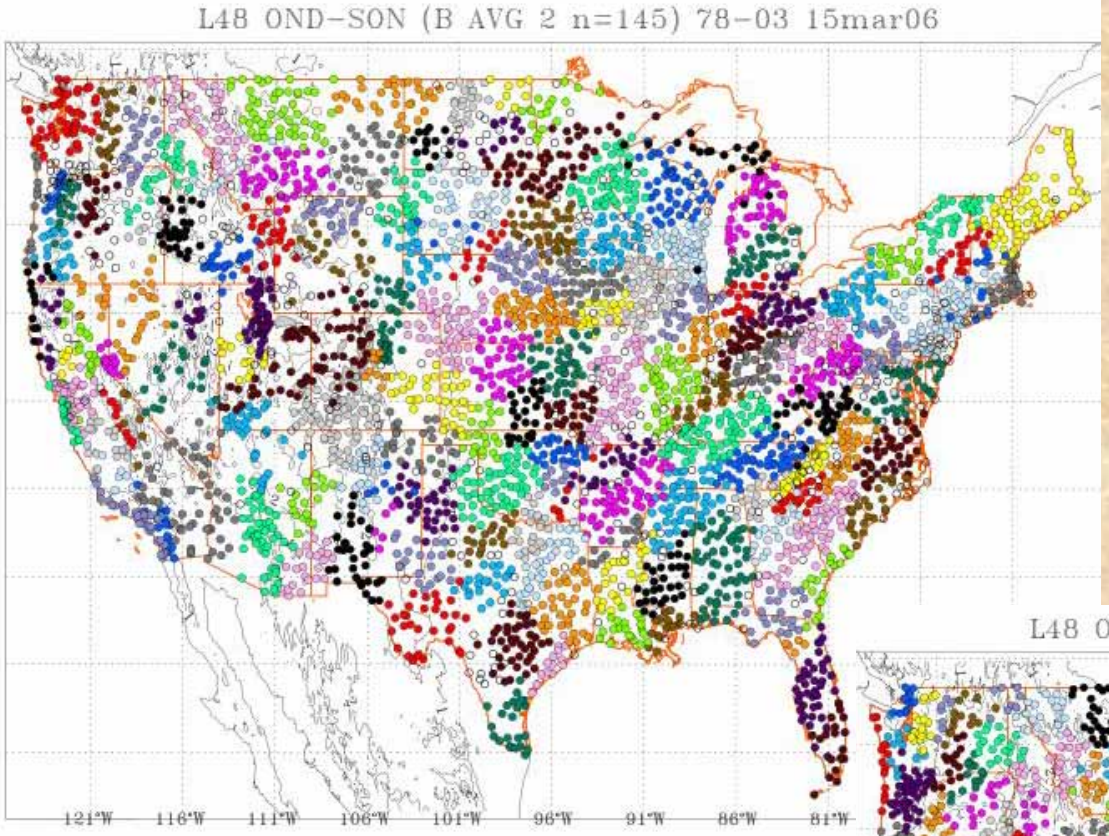
Precipitation cores (final =7352 of 7660, or 96%)



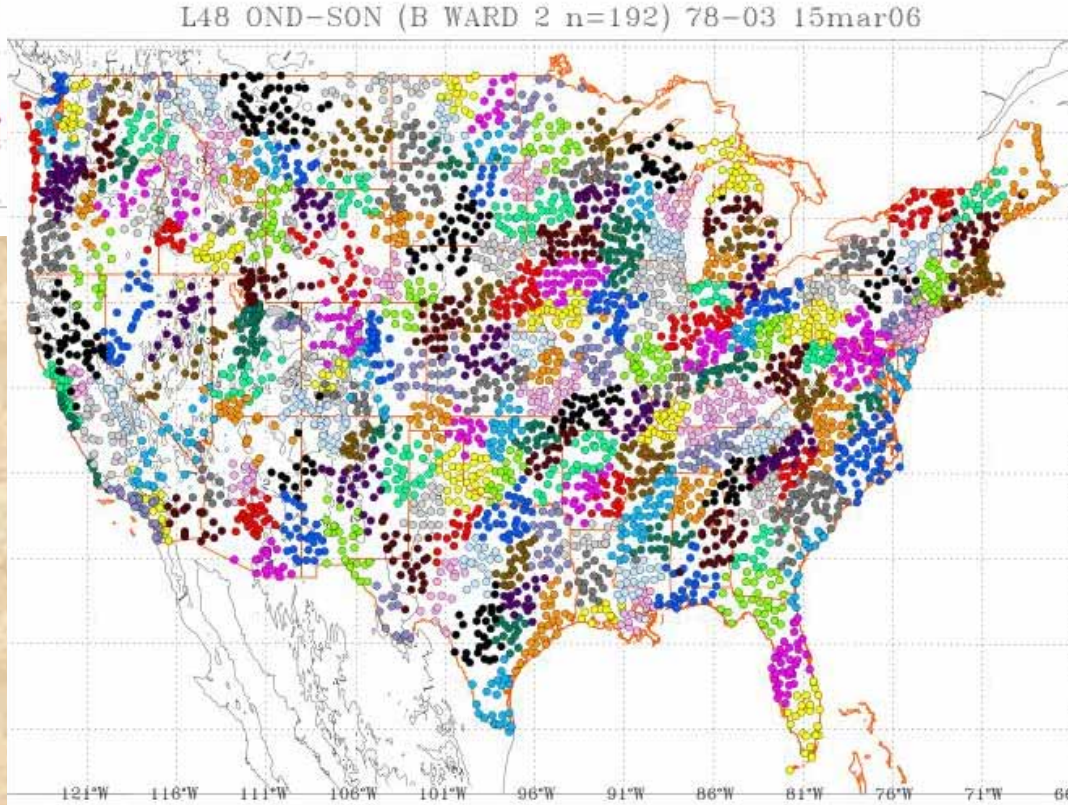
Representativeness of new precipitation cores



Seasonal correlations between new P cores & COOP/SNOTEL sites - note lack of blue!

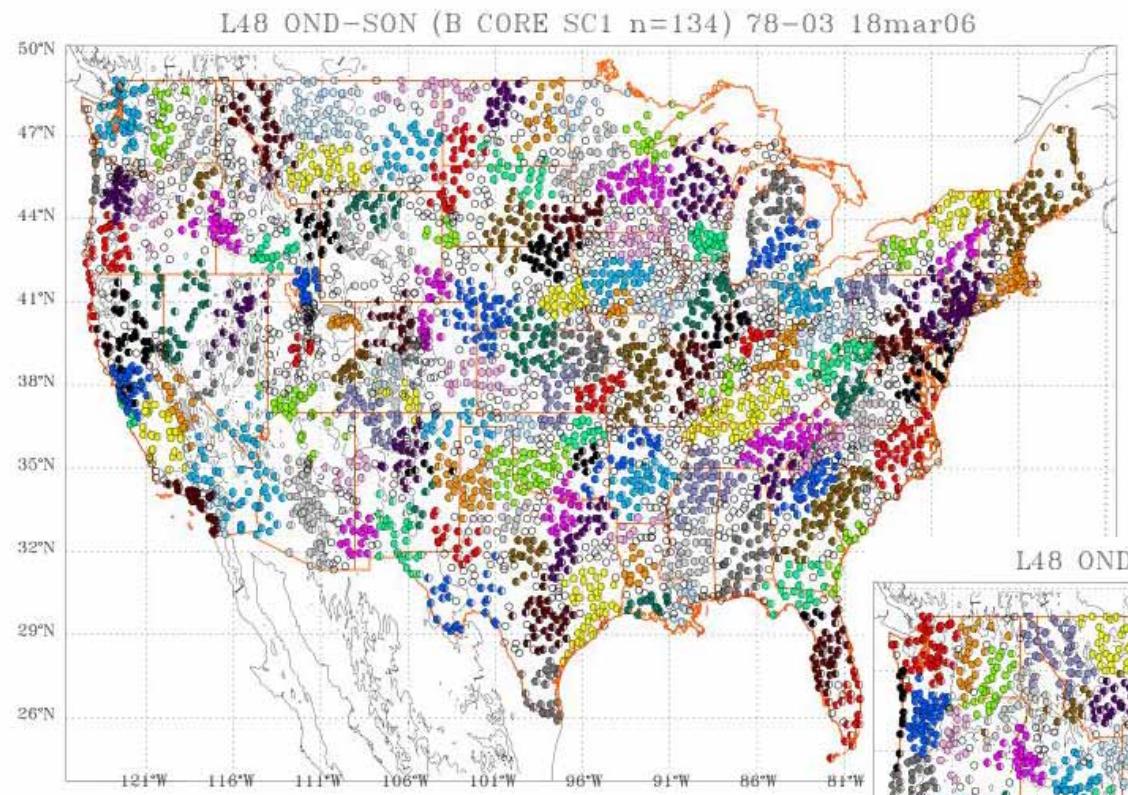


Temperature & precipitation "Average" (left) & "Ward" (bottom) combined clusters

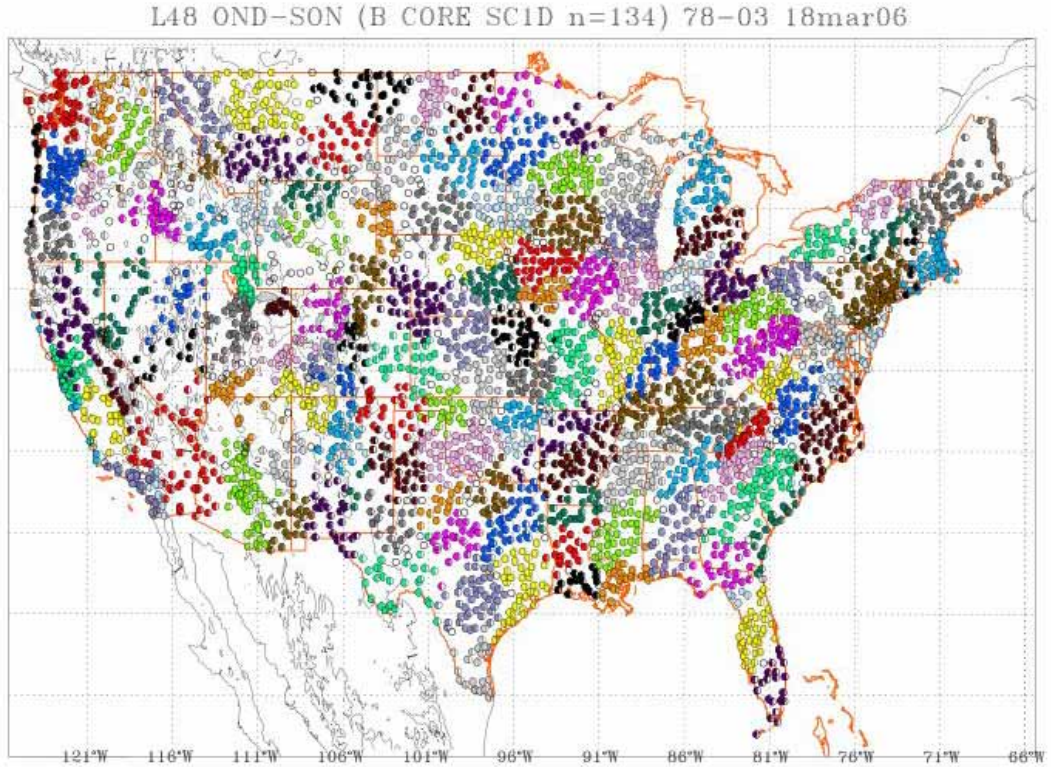


Using standardized time series for temperature and precipitation, the joint analysis produced clusters that preserved features from both T & P clusters.

Temperature and Precipitation Cores

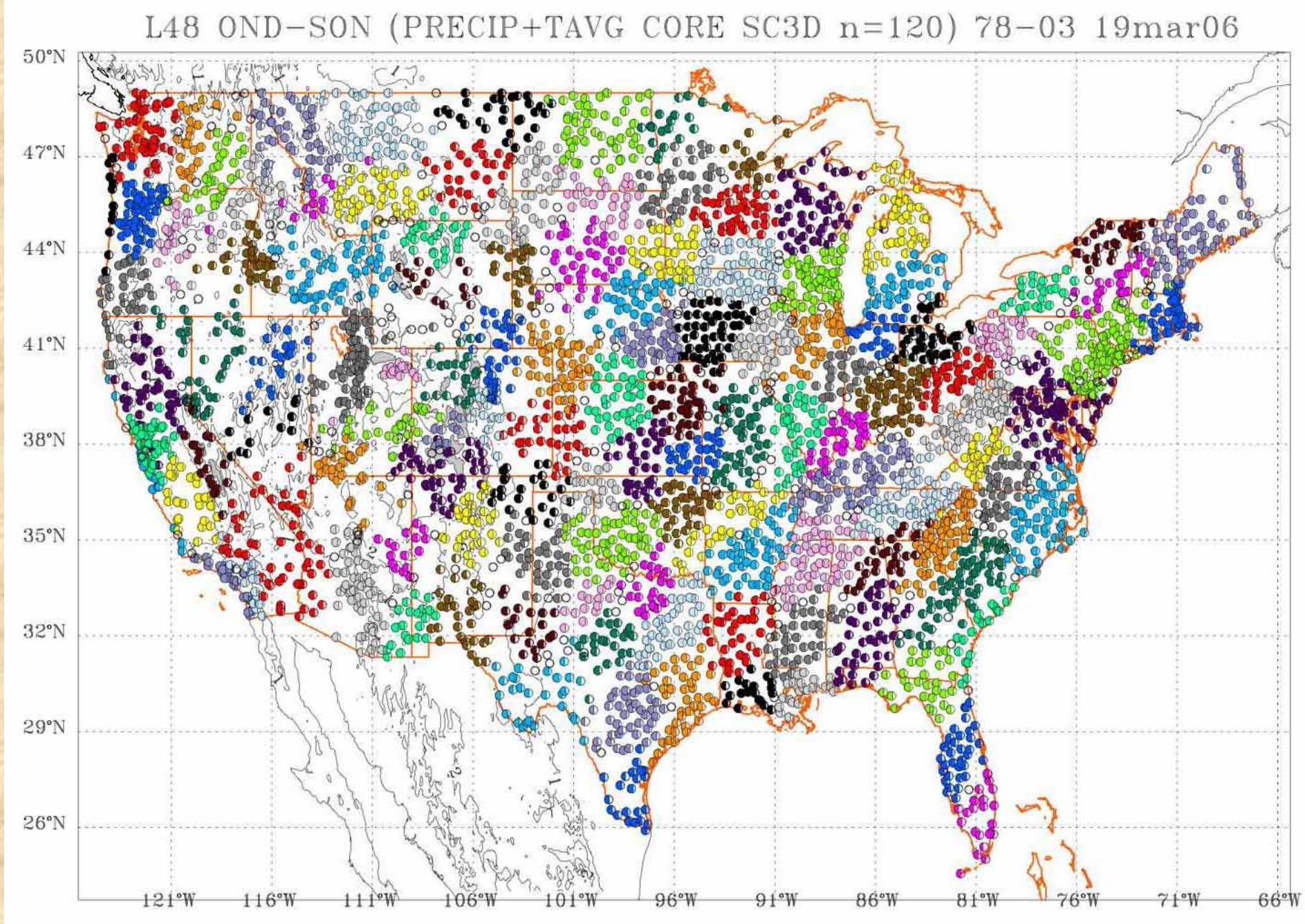


Cross-section of T&P clusters (AVG&WARD) - "Seed" cores (left), and after final "ISE" iteration (bottom). I=Insertion; S=Swap; E=Elimination.

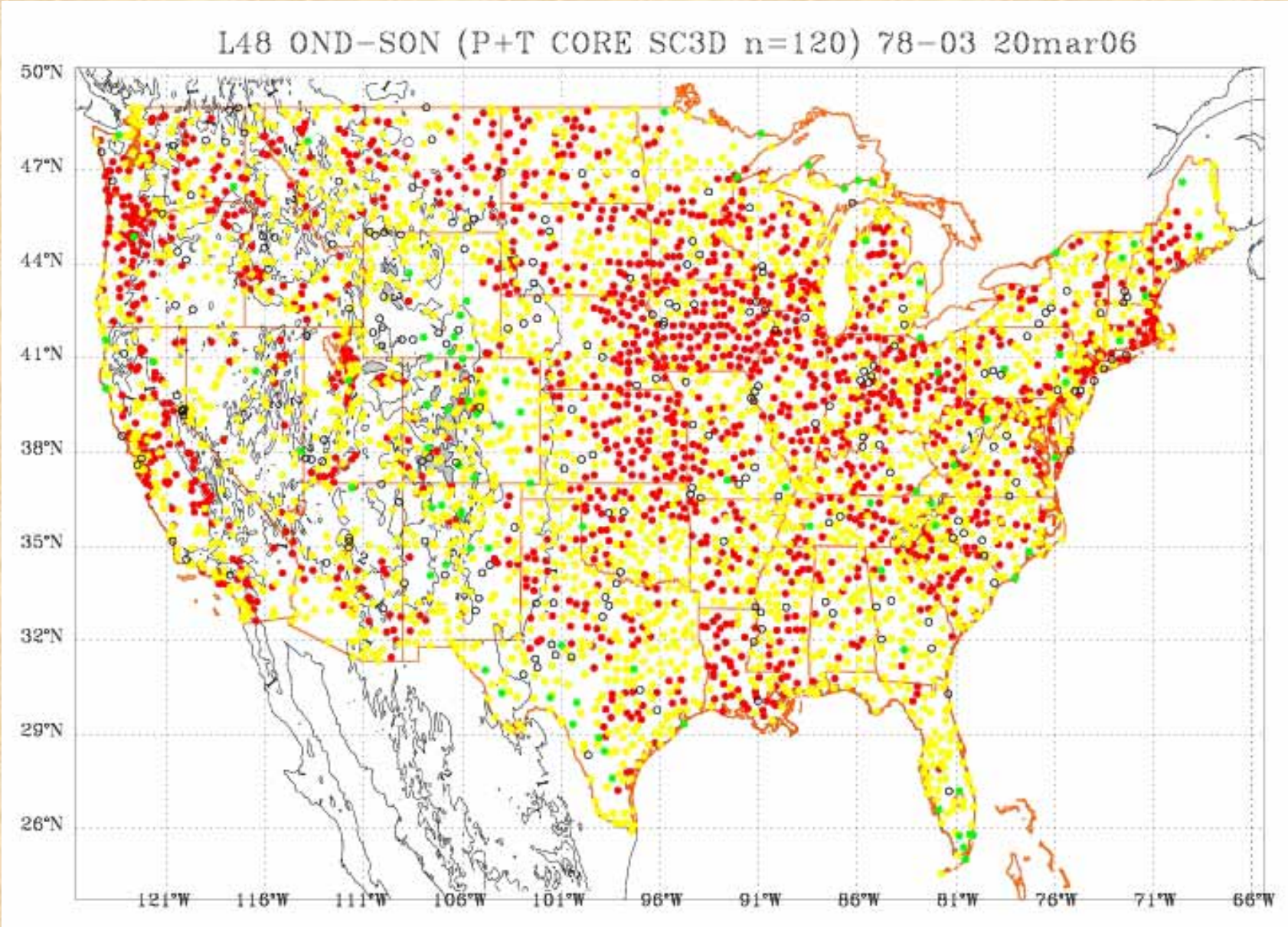


Initial number of included stations: 3310 out of 4370; final count: 4139 out of 4370 (>95%). Issue: collinearity of closest clusters ($r \geq 0.90$).

T&P cores (final version = 4159 of 4370, or 95%)



Representativeness of new climate divisions



Seasonal correlations between new T&P cores and COOP sites - note lack of blue & green!

Summary

- After a ‘long and winding road’, we now have a fairly complete set of new ‘Climate Divisions’ that are based on statistical associations rather than non-climate attributes.
- Within each new climate division, one can pick those stations that are best related to the divisional average to create easily updated climate indices, useful to both the climate monitoring community as well as for climate prediction verification.
- While current SNOTEL sites are not included in the joint temperature&precipitation divisions, they are part of the precipitation-only divisions, and we aim to include them in the joint divisions as well.

Next Steps

- Deal with 5% unassigned stations, including SNOTEL (assign to closest new climate division (corr)?);
- Sensitivity to changing temporal resolution (pentads)?
- In regions of high station density, as well as clear gradients in the station means, add “subdivisions” for further differentiation based on 1st moment statistics (seasonal cycle of T&P)?

- **Become a ‘beta-tester’ !**

- **Workshop this summer to fine-tune these results**