A Large FV3GFS Ensemble in a Reanalysis System

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Outline

- Introduce CORe
- How does CORe use Ensembles
- Results of CORe
- How CORe analysis includes uncertainty and can be used in ensemble models
- Some of the software used and could be reused
- Future Work

What is CORe (Conventional Observation Reanalysis)

- Future climate reanalysis from NCEP
- Replacement for the NCEP/NCAR Reanalysis for climate monitoring by the Climate Prediction Center (CPC) (early 2024)
- Modern model: FV3GFS, 64 vertical levels, C128 (0.7 degree resolution)
- Modern data assimilation: Ensemble Kalman Filter
- No satellite observations aside from AMVs and those used by SST, snow analyses!

  Trade off between better climate trends vs accuracy

  ERA-5 did a fine job with reprocessing the satellite data but some problems

How Does CORe Use Ensemble?

- 80 ensemble members at “full” resolution C128 (0.7 degree resolution)

  ensemble resolution = analysis resolution

- Each member produces an equally likely analysis, unlike the hybrid system
- The “primary” CORe reanalysis is the ensemble mean, probabilistic
- Spread of the ensemble becomes the background error covariance (BEC) for DA

  Eliminates the problem of recomputing the BEC when observation network changes

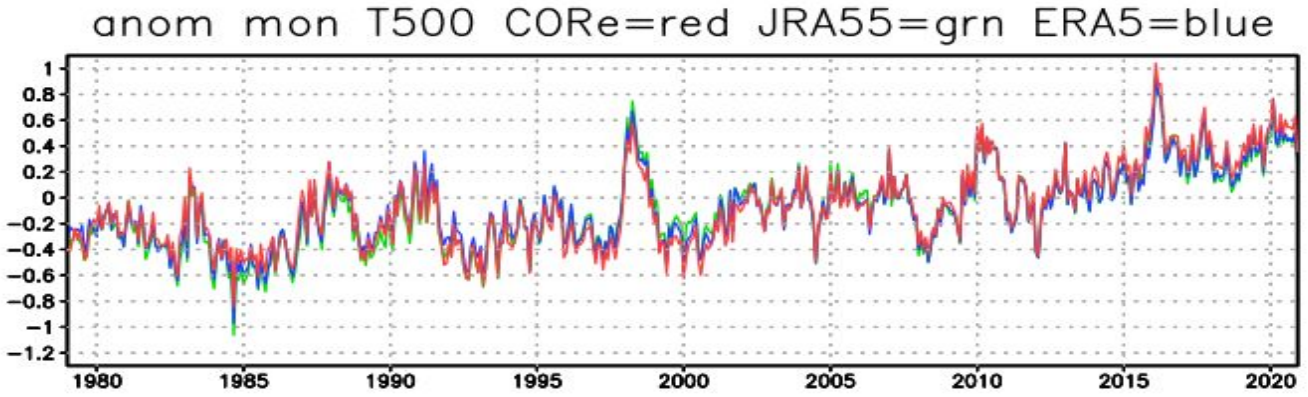
  Most reanalyses used the same BEC for the entire reanalysis period, practical vs ideal

  JRA-55: 1972-present: static BEC based on operational system,

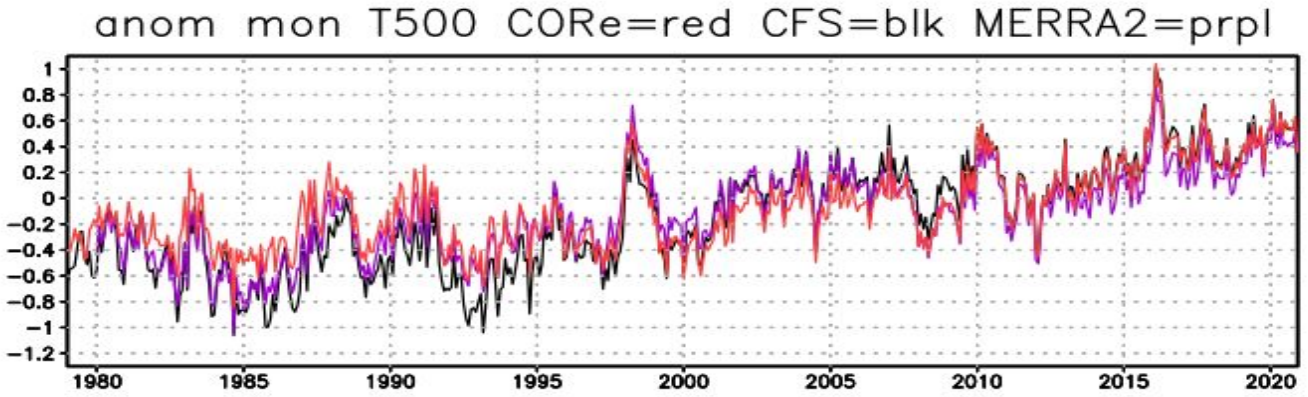
  1958-1971: used 1972+ static BEC inflated by 1.8

  ERA-5: presatellite, early satellite, modern satellite static portion of BEC

  Some dynamic influence by having used an ensemble

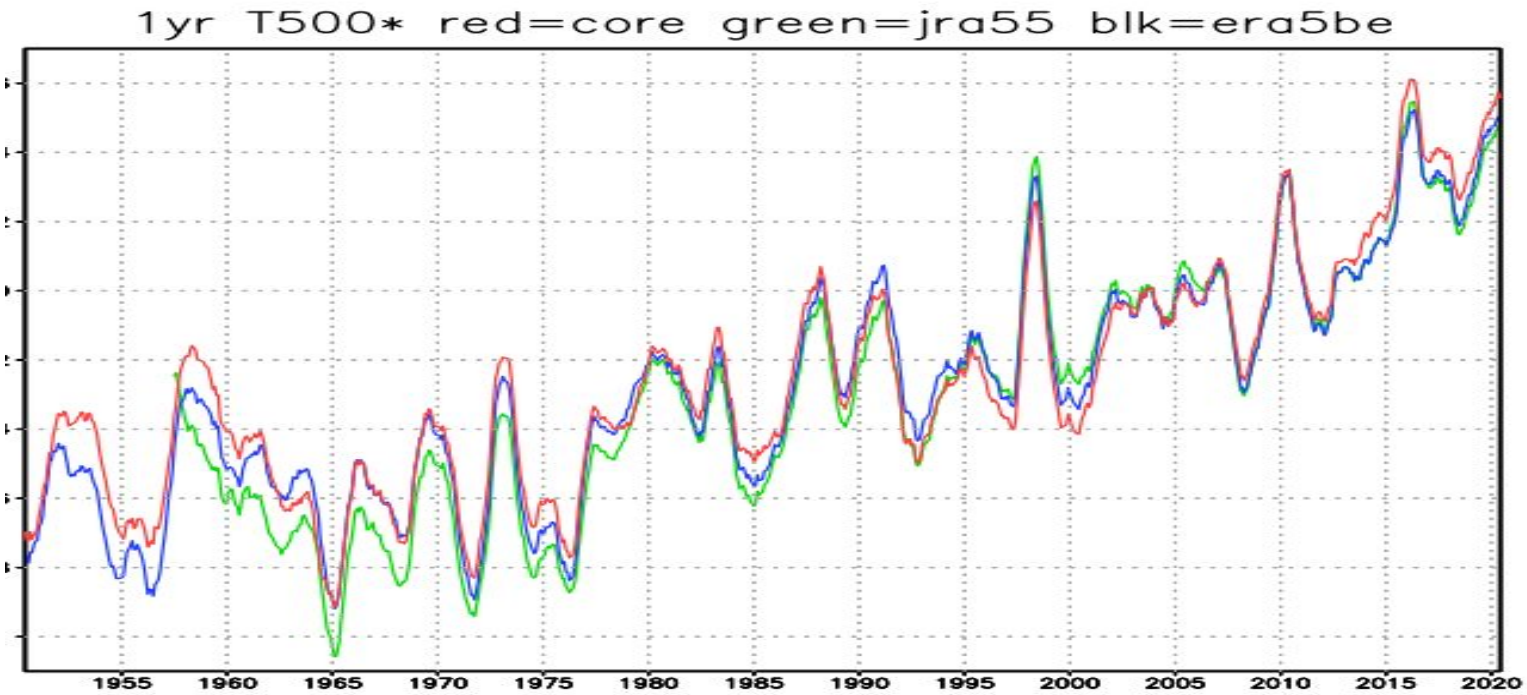


CORe
JRA-55
ERA-5



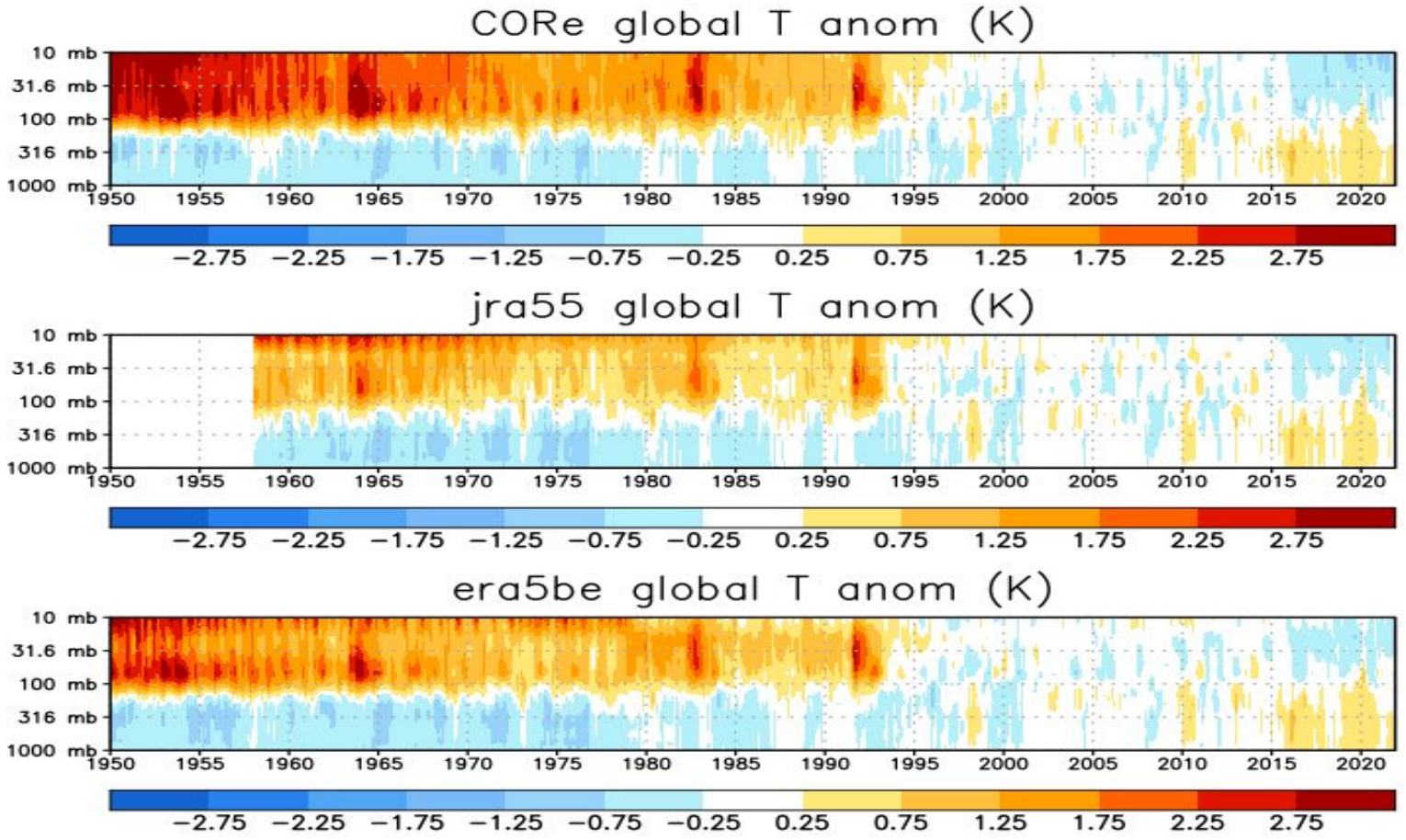
CORe
CFSR
MERRA2

Global T500, 1979-2020, 1991-2020 climatology removed: CORe, ERA-5, JRA-55 consistent; CFSR and MERRA-2 deviate more from CORe. Interval = 0.2C



COReJRA-55ERA-5

Global T500 anomaly with one-year running mean for 1950-2020. More differences in early period. Good for 70-year trend. Less so for decadal trend in the early record. Interval = 0.2C



CORe

JRA-55

ERA-5

Global T anomaly 1000-10 mb, 1950-2020. Good agreement in troposphere, and CORe is slightly warmer in early period stratosphere. Much of the warmth in the early CORe stratosphere is from the Southern hemisphere (not shown).

Consistent trends ⇒ the real answer?

Different treatments of satellites

ERA-5: satellite observations including all-sky radiances
JRA-55: satellite observations but not including cloudy radiances
CORe: no satellite observations aside from Atmos. Motion Vectors

Different data assimilation systems

ERA-5: 4D-var with weighted average of static and dynamic BEC
JRA-55: 4D-var with static BEC, 1958-1971 and another for 1972+
CORe: EnKF, dynamic background error covariance (BEC)

Different models and QC procedures

However, most of the conventional observations will be common. So observation biases could produce spurious trends.

CORe analyses are different than traditional analyses

Analyses are ensemble means

smoother

uncertainty in the analysis yields smoother fields

example:

Hurricane Flora, 00Z Oct 4, 1963 was just south of Haiti,

landfall shortly later

cons: 0.70 degree resolution model cannot resolve

pros: ensemble mean differs for 10% and 90% values

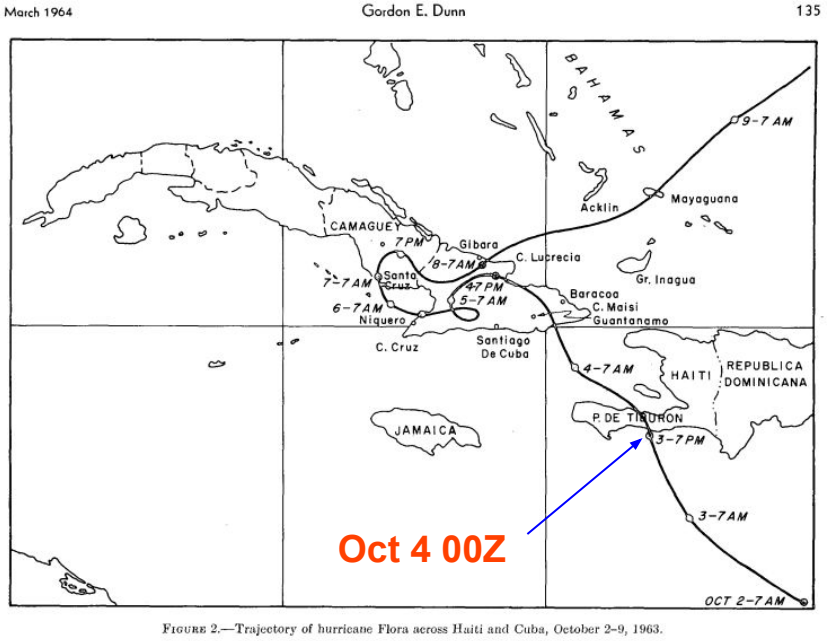
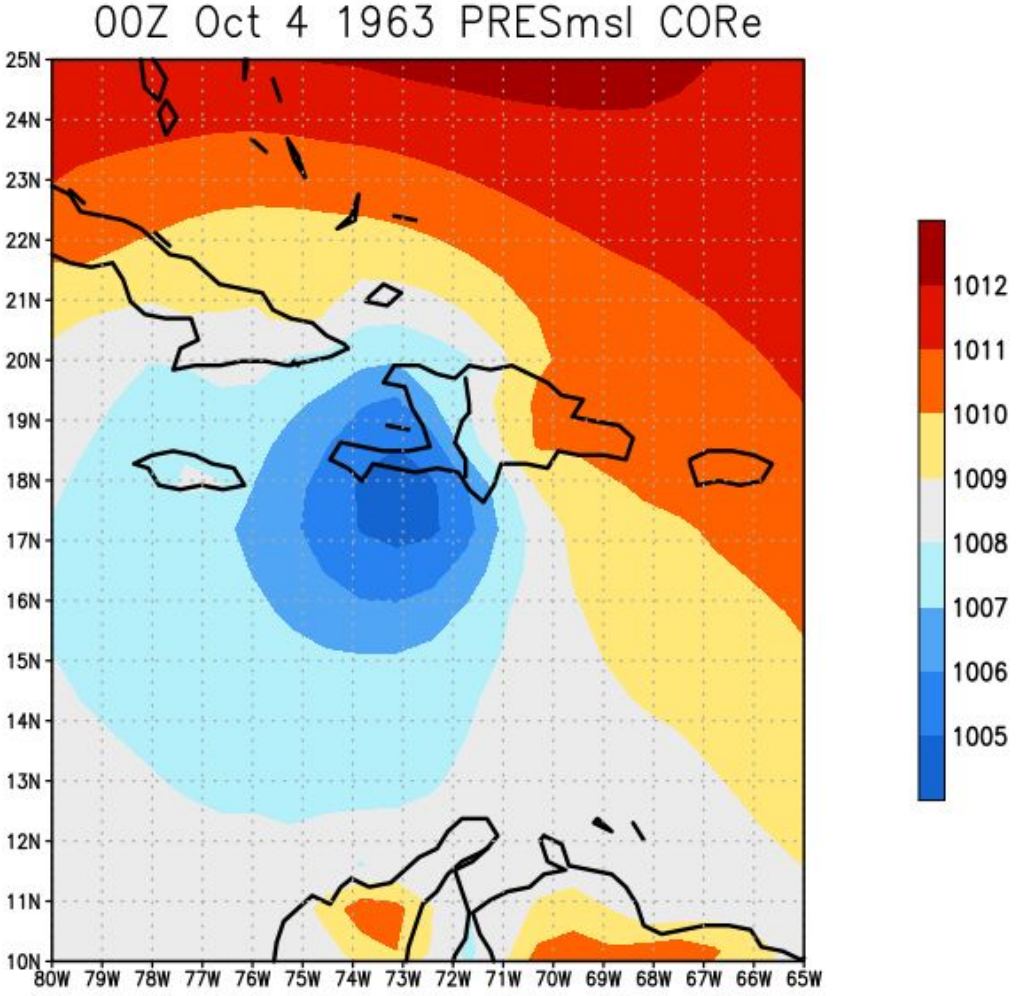


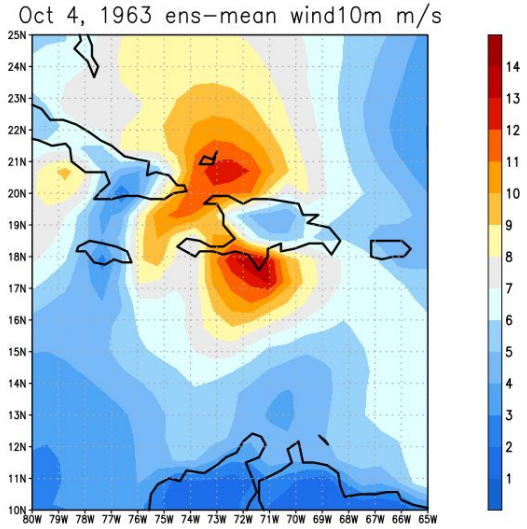
FIGURE 2.—Trajectory of hurricane Flora across Haiti and Cuba, October 2–9, 1963.

Above: Dunn and Staff, Mon. Wea. Review. 1964, Vol 99, No. 3.

Right: CORe put Flora slightly south of actual position.



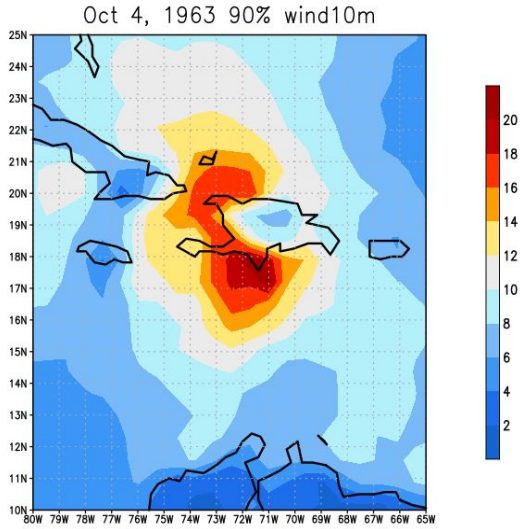
Ensemble Mean

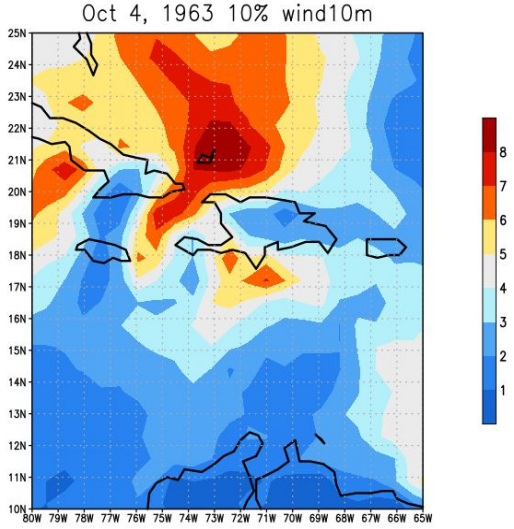


10m wind speed south of Haiti:

10%: peaks at 7 m/s
ens-mean: peaks at 14 m/s
90%: peaks at 21 m/s
95%: peaks at 23 m/s (not shown)
max: peaks at 27 m/s (not shown)

90%





10%

Some Uses for the CORe Ensemble

Not the resources to save all 80 member data for 70 years. So had to make some choices.

Saved flux file for 80 members every 3 hours
- drive ocean model ensemble
- drive land surface ensemble

80 member flux and RV/LV pgb file (reduced variable/limited vertical resolution)
- probabilistic analysis .. use ??

Statistic files from flux and RV/LV pgb file.
- low-volume-data probabilistic analysis

Saved initial conditions for 6 members every 00Z, forecast experiments

Software

Fcst model: FV3GFS with some modifications such as ozone
DA programs: included with FV3GFS build (gsi, enda, cycle, etc)
ncep-post: some modifications

Software developed for CORe

gfsnemsio2grb: converts gfs nemsio file to grib2, uses wgrib2lib
based on program by Jun Wang
spost: produces simple post, uses wgrib2lib
wgrib2 -ens_processing: generates statistics file

Other used software

pywgrib2_s: yet another python library for grib, uses wgrib2lib, numpy

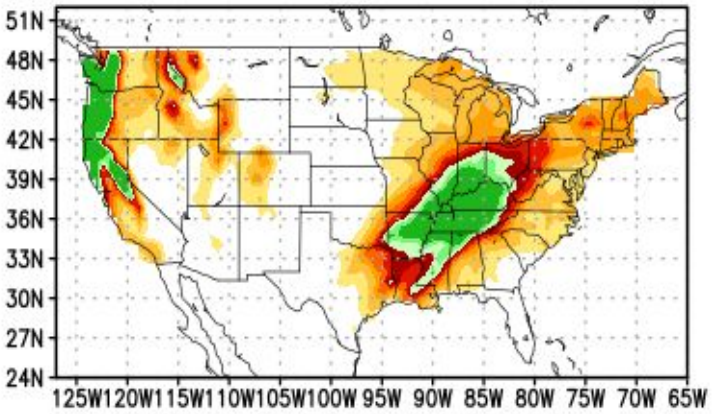
Future Work

Read netcdf diagnostic files, and create an “atlas” of observation statistics

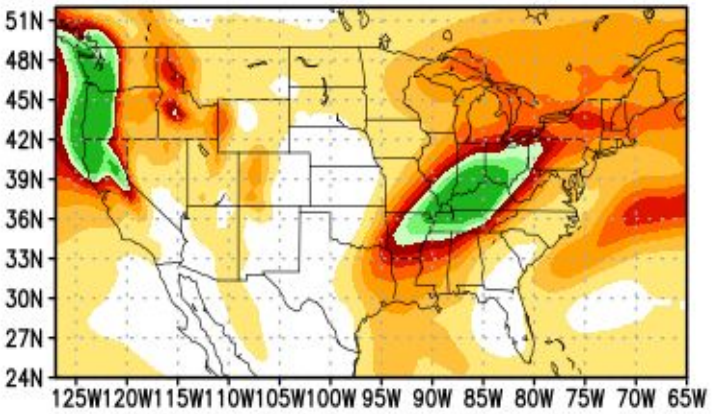
Atlas = easy-to-use datasbase

Extend CORe to 1930+. The analyses over most of the globe will be poor because of the lack of observations but there may be enough observations over the CONUS to get reasonable CONUS/dust bowl analyses.

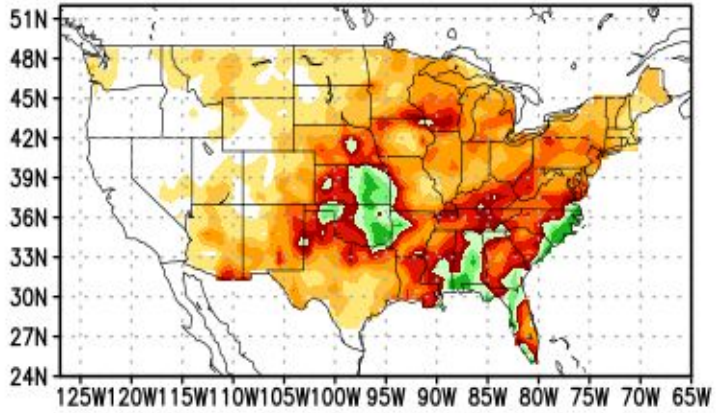
jan1950 Obs Precip [mm/day]



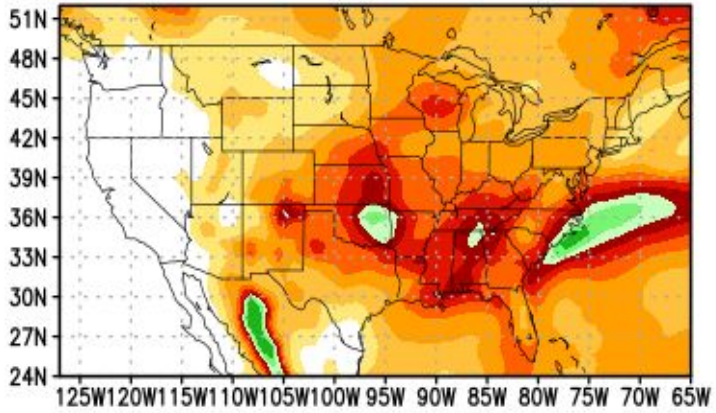
jan1950 CORe Precip



jul1950 Obs Precip [mm/day]



jul1950 CORe Precip



Summary

Showed results of CORe
Showed a use of ensemble in data assimilation (CORe)
Suggested how CORe can be used in ensemble models
Showed how CORe analysis includes uncertainty
Listed some of the software used and could be reused.