Ensemble Hindcaster for Precipitation, Temperature, & Streamflow Ensemble Forecast Verification

Training Documentation

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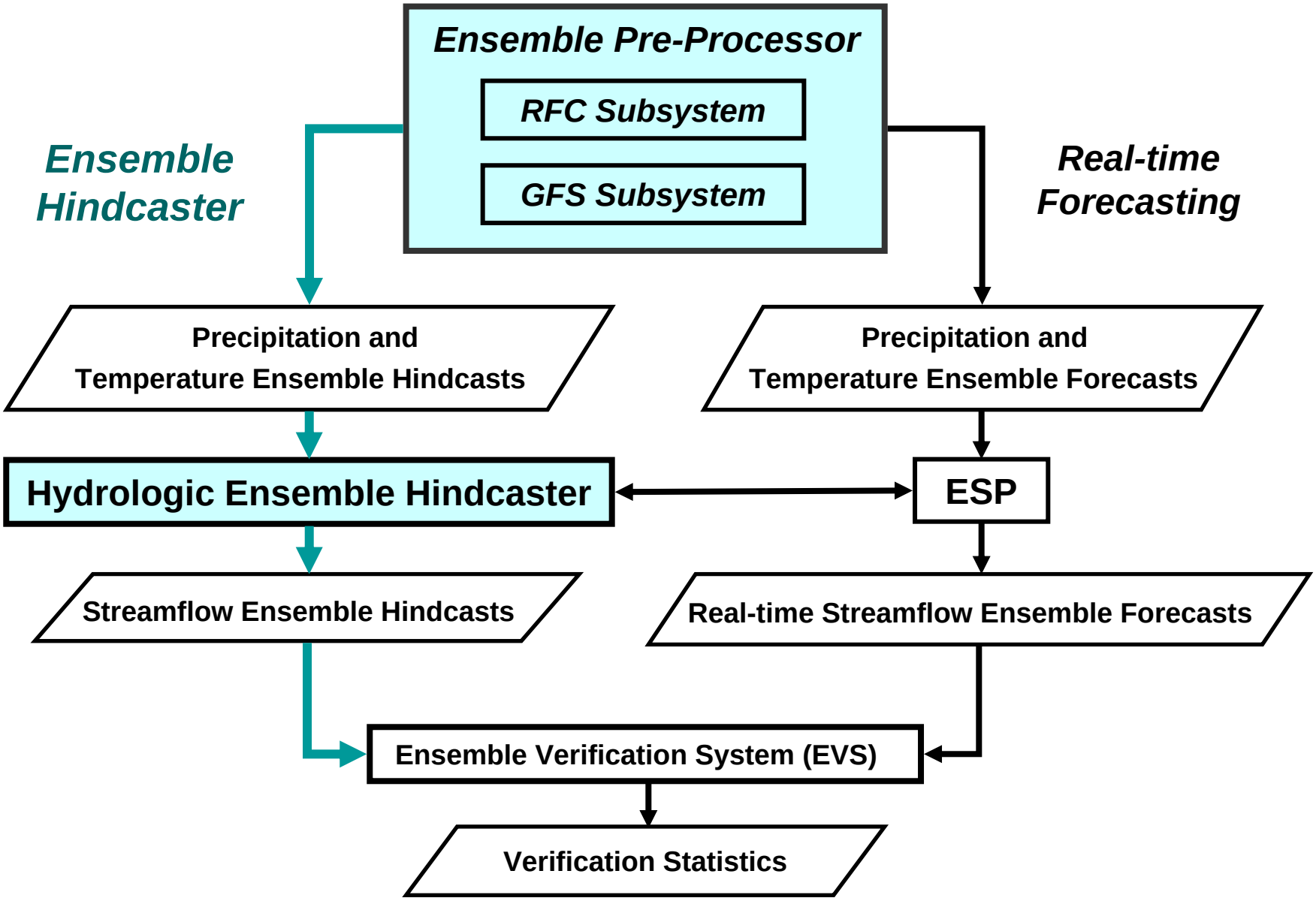
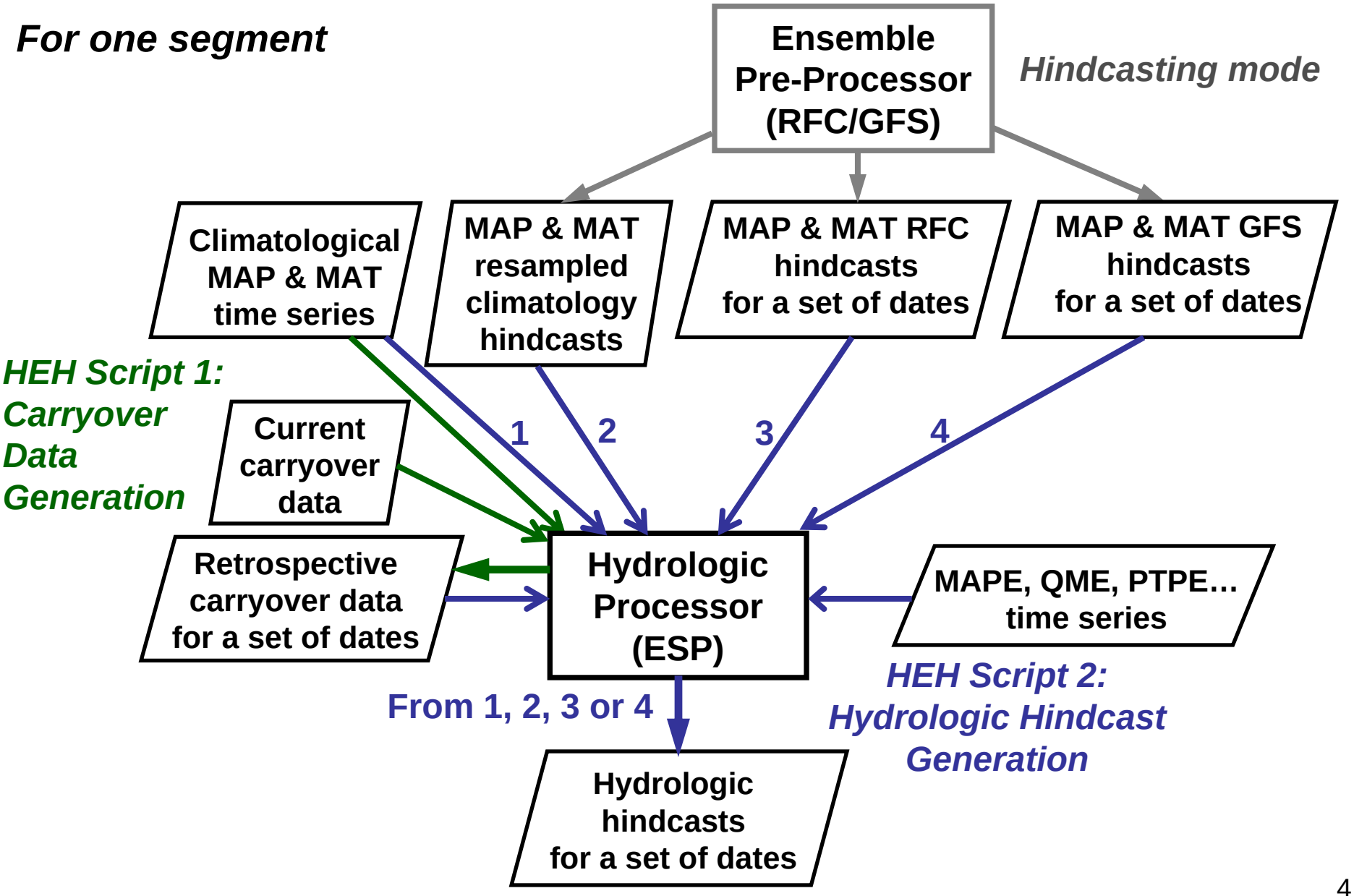
Ensemble Hindcaster Components



Ensemble Hindcaster

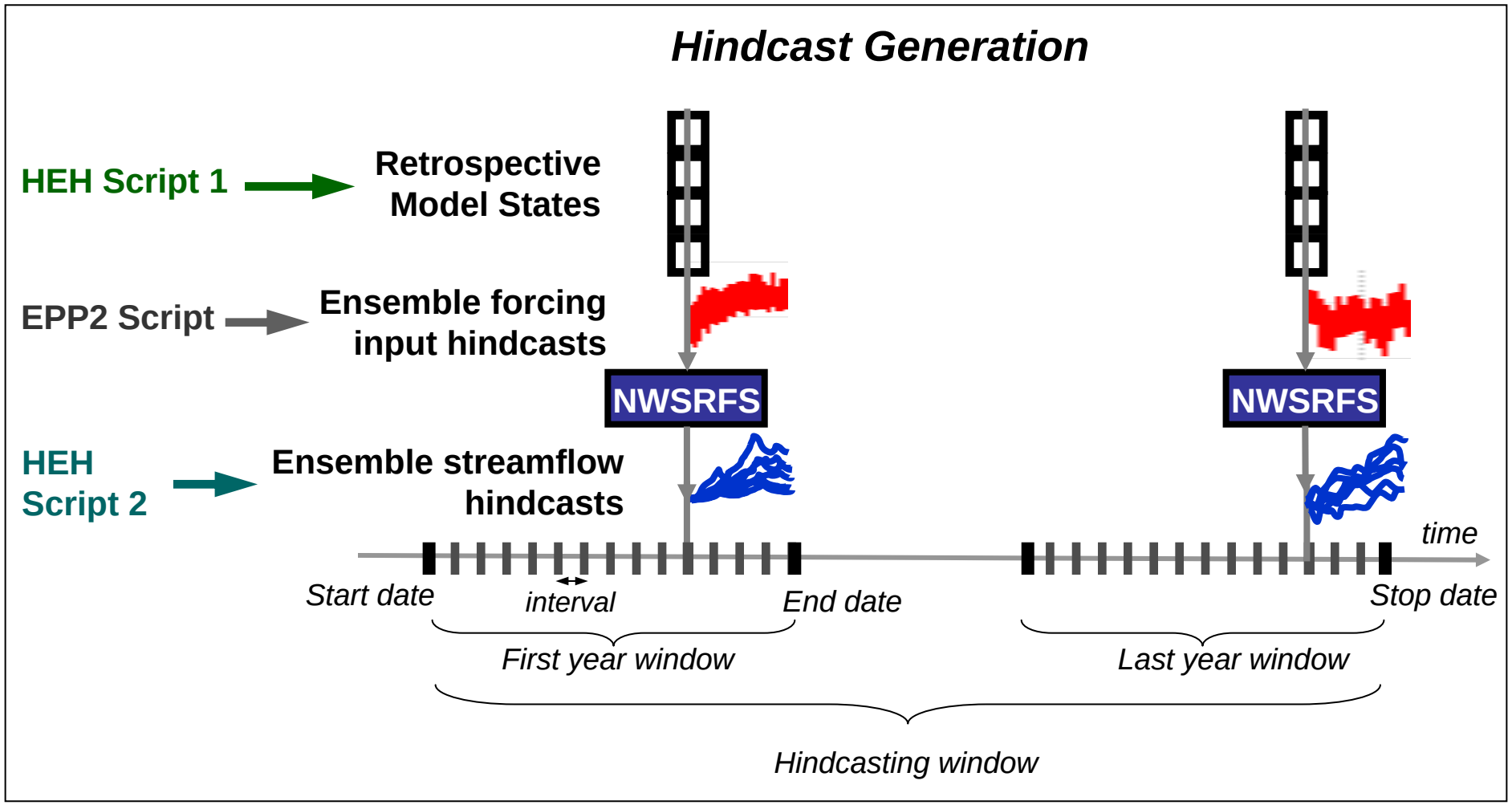
- Goal: capability for systematic hindcasting to evaluate probabilistic forecast performance and validate ensemble science
- Existing capabilities:
  - limited capability with ETSGEN gui with operational ESP
  - hindcasting capability for CBRFC Pre-Processor
  - limited capability at OHD for short-term precipitation and temperature ensembles produced by experimental EPP
- Benefits:
  - improve predictions and validate improvements relative to forecast reliability and skill
  - serve RFC's operational need for ensemble system calibration and forecast validation
- Current Ensemble Hindcaster prototype:
  - Ensemble Pre-Processor EPP2: Korn shell script for hindcasting mode
  - Hydrologic Ensemble Hindcaster (HEH): 2 Korn shell scripts

Ensemble Hindcaster: Data & Processes



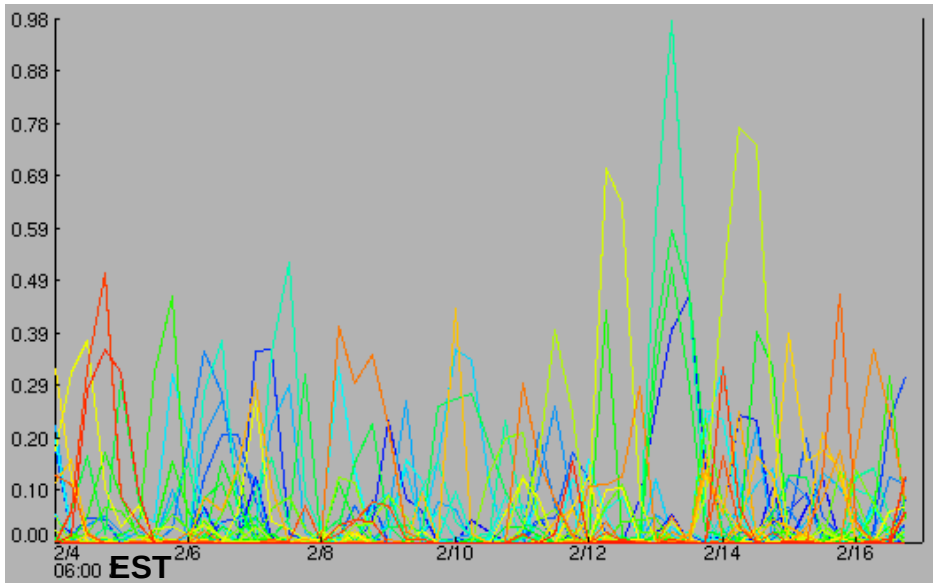
Ensemble Hindcaster: Processes

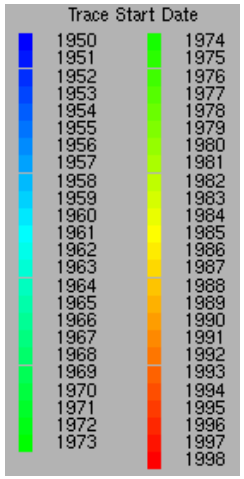
- Hindcast generation: done once for a given forecast scenario and a given verification time period



EPP2 Hindcaster: Output (a)

- Generate MAP & MAT hindcasts without RFC/GFS parameters: re-sampled climatology ensembles

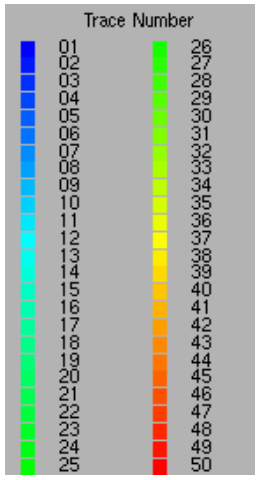


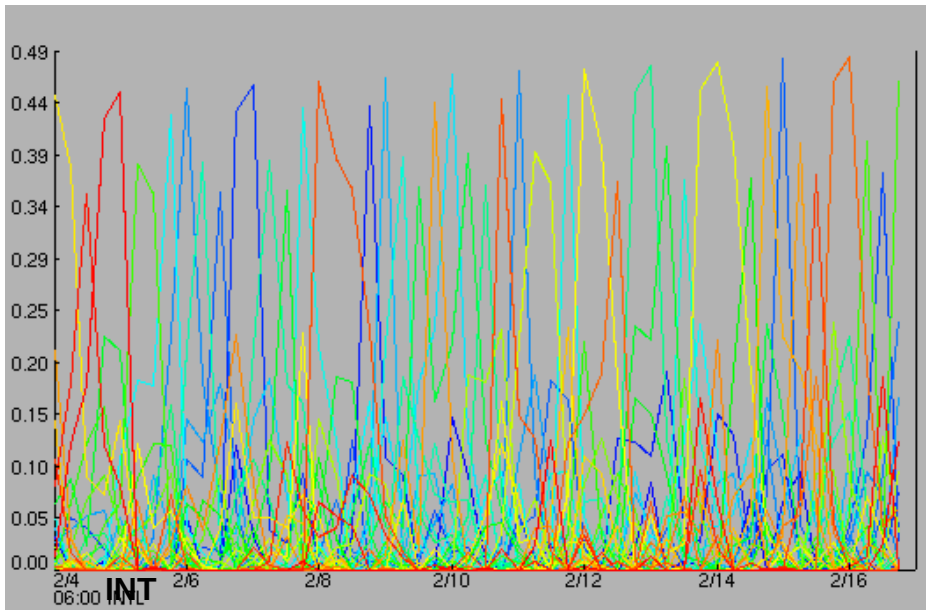


Precipitation (IN), Huntingdon, MARFC

Climatology MAP time series in local standard time

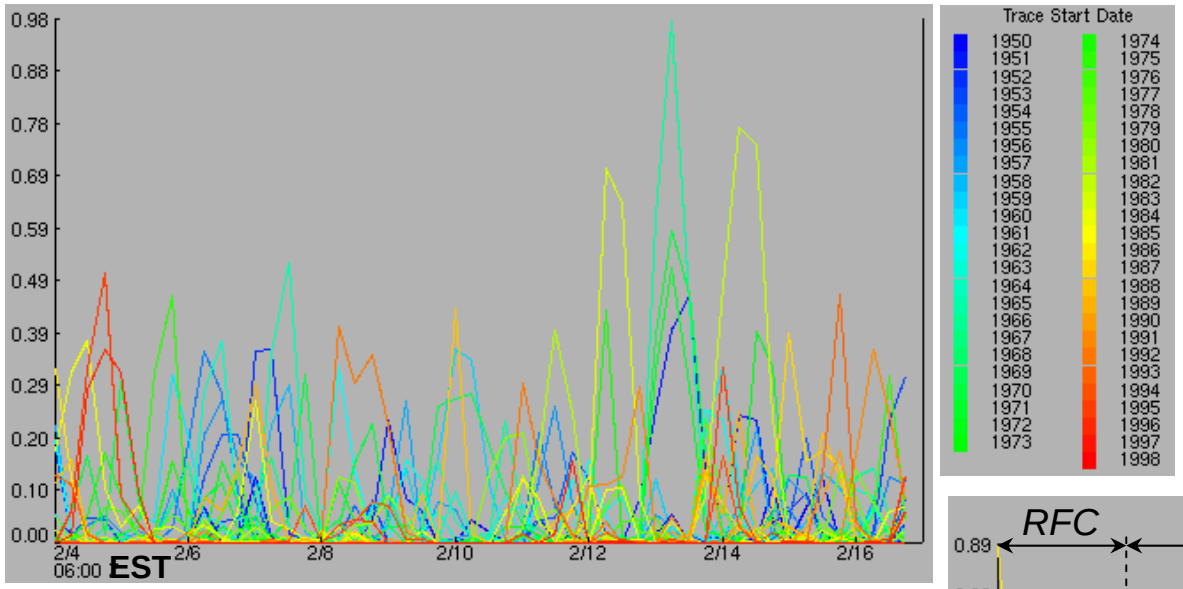
Re-sampled climatology MAP ensembles in internal time





EPP2 Hindcaster: Output (b)

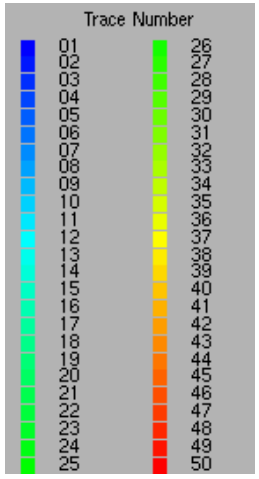
- Generate MAP & MAT hindcasts with RFC/GFS parameters: short-term RFC/GFS ensembles blended with re-sampled climatology ensembles

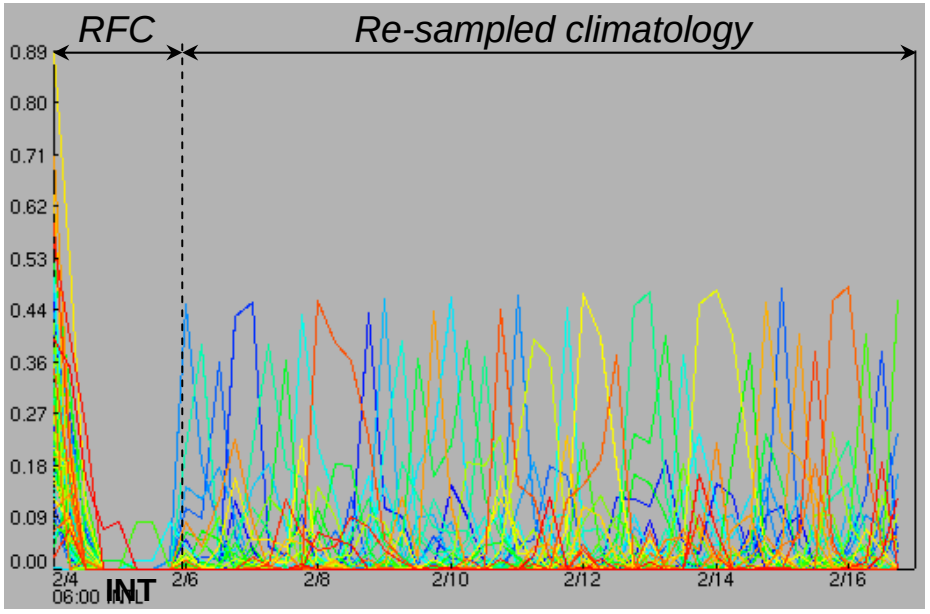


Precipitation (IN), Huntingdon, MARFC

Climatology MAP time series in local standard time

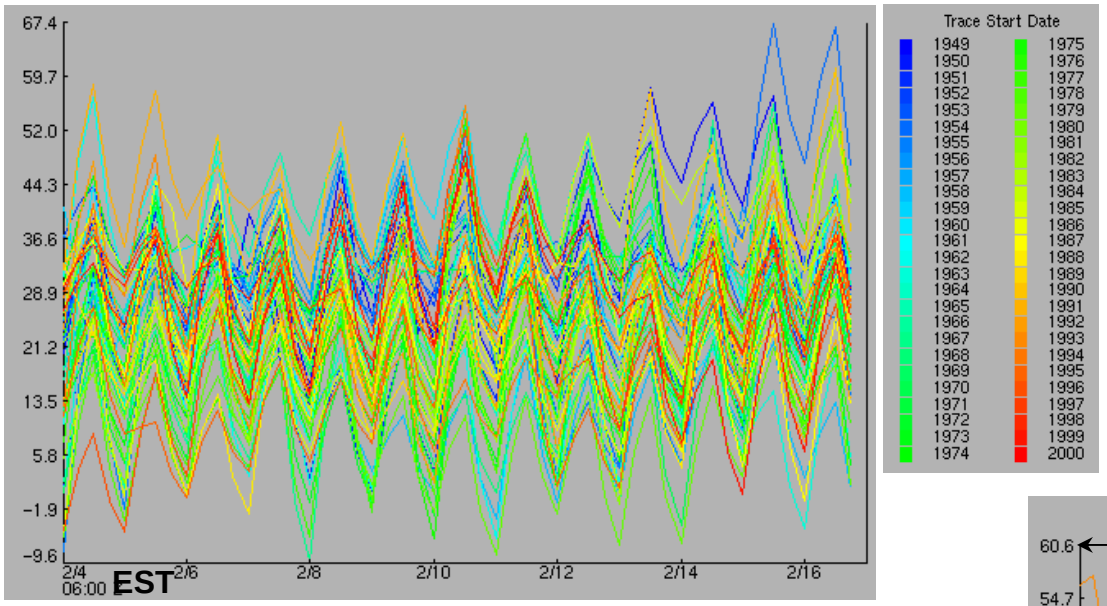
Short-term RFC & re-sampled climatology MAP ensembles in internal time





EPP2 Hindcaster: Output (c)

- Generate 6-hr MAT hindcasts with RFC/GFS parameters from daily maximum and minimum temperature ensembles

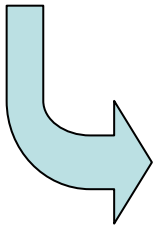


User-defined temporal disaggregation process for each time step:

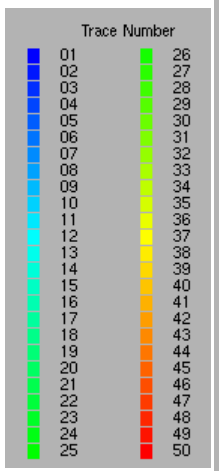
$T_6 = T_{min} + TP \times (T_{max} - T_{min})$

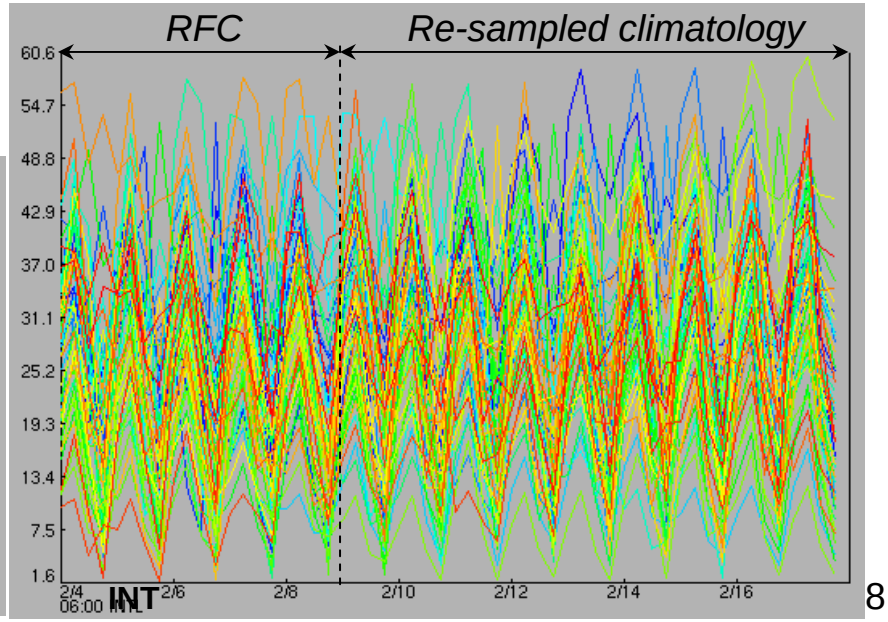
Temperature (DEGF), Huntingdon, MARFC

Climatology MAT time series in local standard time



Short-term RFC & re-sampled climatology MAT ensembles in internal time





EPP2 Hindcaster: Output (d)

- Archiving data to run Hydrologic Ensemble Hindcaster (HEH) with various input hindcasts:

1) Climatology time series:

<ts_ID>. MAP06 and <ts_ID>. MAT
in $(calb_area_ts_dir)/climato/

2) Re-sampled climatology hindcasts:

<ts_ID>. MAP06 and <ts_ID>. MAT
in $(calb_area_ts_dir)/pre_climato/

3) Short-term RFC/GFS and re-sampled climatology MAP & MAT hindcasts based on start date yyyy/mm/dd:

<yyyy><mm><dd>.<ts_ID>. MAP06 and

<yyyy><mm><dd>.<ts_ID>. MAT
in $(calb_area_ts_dir)/pre_short/ → $(preadj_outts_dir) for HEH

Examples for Hindcast files starting on 02/04/1998 for HUNP1JUN segment:
19980204.huntingdon.MAP06 and
19980204.huntingdon.MAT

Hydrologic Hindcaster: Script 1 (a)

- Generates retrospective carryover information from existing carryover data (fs5files) running OFS FCST ESP function in historical mode

FCST input control file for 02/03

```
STARTESP 0526/2005/
WINDOWS(1) 0526/2005/ 0205/2006/
NUMCOSAV(1) 0203/2006/24EST
PERMWRIT(0)
HISTSIM(1)
REGULATE(1)
TSUNITS(1) 91 92 93 94 95
HISTWYRS 1949 1998
ONESEG HUNP1JUN
@COMP ESP
@STOP
```

Current carryover date

Carryover date to be saved on 24hr local time zone

Historical simulation

Historical water years to use

FCST output file: saving carryover data, 02/03/1950-1998

```
[...]
**NOTE**  CARRYOVER WILL BE SAVED FOR: 02/03/50/24 EST
**NOTE**  CARRYOVER WILL BE SAVED FOR: 02/03/51/24 EST
**NOTE**  CARRYOVER WILL BE SAVED FOR: 02/03/52/24 EST
**NOTE**  CARRYOVER WILL BE SAVED FOR: 02/03/53/24 EST
**NOTE**  CARRYOVER WILL BE SAVED FOR: 02/03/54/24 EST
[...]
**NOTE**  CARRYOVER WILL BE SAVED FOR: 02/03/96/24 EST
**NOTE**  CARRYOVER WILL BE SAVED FOR: 02/03/97/24 EST
**NOTE**  CARRYOVER WILL BE SAVED FOR: 02/03/98/24 EST
[...]
```

Output: 1 carryover data file in carryover directory:

HUNP1JUN.02.03.24.EST

Hydrologic Hindcaster: Script 1 (b)

- For a range of hindcasting dates, the ksh script generates retrospective carryover data from existing carryover data (fs5files) running iteratively OFS FCST ESP function in historical mode

- User-defined variables:
  - range of carryover dates: initial start date, initial end date, time interval between 2 dates, hindcasting stop date
  - ESP start date with carryover info in fs5files
  - time zone (XST)
  - range of historical water years
  - segment / forecast group information: segment option, ID
  - tokens:
    - ofs fcst input directory, ofs fcst output directory
    - ofs fs5files directory
    - calibration time series directory
    - ens files directory: carryover data saved in $(ens_files)/carryover, simulated flows saved in $(ens_files)/espts

- Output:
  - carryover data files: <segment_ID>.<month mm>.<day dd>.24.<time zone XST>
  - simulated flow (HS) files: <segment_ID>.<ts_ID>.QINE.06.HS

Hydrologic Hindcaster: Script 1 (c)

Example for 1 forecast group

```
#  Set the initial start date
   first_run_start_mon=09
   first_run_start_day=30
   first_run_start_year=2005
#  Set the initial end date
   first_run_end_mon=10
   first_run_end_day=02
   first_run_end_year=2005
#  Set the time interval
   interval=1
#  Set the stop date for running hindcasting
first_round_stop_date=20060429
#  Define the ESP start date with available carryover data
   esp_start_date=0516/2005/
#  Define the time zone code
   time_zone='CST'
#  Define the historical years for generating carryover data
   start_hist_year=1985
   end_hist_year=2005
#  Define the segment or forecast group option
   segment_option=0
#  Define id for segment or forecast group
   fgroup_ID=STENS
#  Set environment variables (tokens)
   export ofs_fs5files=${ofsdir}/files/${name}/fs5files
   export fcst_input=${ofsdir}/input/${name}/fcst
   export fcst_output=${ofsdir}/output/${name}
   export ens_files=${ensdir}/files/${name}/abrfc2006
   export espts_dir=${ens_files}/espts
   export calb_area_ts_dir=${calbdir}/data/area_ts/${name}/abrfc_verif/climato
```

Hydrologic Hindcaster: Script 1 (d)

Example for 1 forecast group

```
#  Loop through the hindcast dates from first start date to stop date
   …
#  for each hindcast date with given start date and end date
  do
#    Create the fcst input file co_gen
     co_gen=${fcst_input}/co_gen
#    Write in input control file
     echo "@SETOPT" > $co_gen
     echo "STARTESP ${esp_start_date}" >> $co_gen
     echo "WINDOWS(1) ${esp_start_date} ${cur_end_date_ofs}" >> $co_gen
     echo "NUMCOSAV(1) ${cur_start_date_ofs}24${time_zone}" >> $co_gen
     echo "PERMWRIT(0)" >> $co_gen
     echo "HISTSIM(1)" >> $co_gen
     echo "REGULATE(1)" >> $co_gen
     echo "TSUNITS(1) 91 92 93 94 95" >> $co_gen
     echo "HISTWYRS ${start_hist_year} ${end_hist_year}" >> $co_gen
     if [ $segment_option -ge 1 ] ; then
        echo "ONESEG ${segment_ID}" >> $co_gen
     else echo "FGROUP ${fgroup_ID}" >> $co_gen
     fi
     echo "@COMP ESP" >> $co_gen
     echo "@STOP" >> $co_gen
#    Run the fcst program
     ofs -p fcst -i co_gen -o co_gen
#    Remove output file in the $(fcst_output) directory
     rm -f ${fcst_output}/fcst_*
     rm -f ${fcst_output}/co_gen.*
#    Compute start date and end date for the next run
      …
  done
```

Hydrologic Hindcaster: Script 1 (e)

Output carryover data files:

<segment_ID>.<mm>.<day>.24.<time zone>

```
demargne@lx8-nhdr OB7 dev> pwd
/fs/ensembles/projects/nwsrfs/ens/files/demargne/abrfc2005/carryover
demargne@lx8-nhdr OB7 dev> ls JO*
JOPM7PQ.01.01.24.CST  JOPM7PQ.02.23.24.CST  JOPM7PQ.04.17.24.CST  JOPM7PQ.06.09.24.CST  JOPM7PQ.08.01.24.CST  JOPM
JOPM7PQ.01.02.24.CST  JOPM7PQ.02.24.24.CST  JOPM7PQ.04.18.24.CST  JOPM7PQ.06.10.24.CST  JOPM7PQ.08.02.24.CST  JOPM
JOPM7PQ.01.03.24.CST  JOPM7PQ.02.25.24.CST  JOPM7PQ.04.19.24.CST  JOPM7PQ.06.11.24.CST  JOPM7PQ.08.03.24.CST  JOPM
JOPM7PQ.01.04.24.CST  JOPM7PQ.02.26.24.CST  JOPM7PQ.04.20.24.CST  JOPM7PQ.06.12.24.CST  JOPM7PQ.08.04.24.CST  JOPM
JOPM7PQ.01.05.24.CST  JOPM7PQ.02.27.24.CST  JOPM7PQ.04.21.24.CST  JOPM7PQ.06.13.24.CST  JOPM7PQ.08.05.24.CST  JOPM
JOPM7PQ.01.06.24.CST  JOPM7PQ.02.28.24.CST  JOPM7PQ.04.22.24.CST  JOPM7PQ.06.14.24.CST  JOPM7PQ.08.06.24.CST  JOPM
JOPM7PQ.01.07.24.CST  JOPM7PQ.03.01.24.CST  JOPM7PQ.04.23.24.CST  JOPM7PQ.06.15.24.CST  JOPM7PQ.08.07.24.CST  JOPM
JOPM7PQ.01.08.24.CST  JOPM7PQ.03.02.24.CST  JOPM7PQ.04.24.24.CST  JOPM7PQ.06.16.24.CST  JOPM7PQ.08.08.24.CST  JOPM
JOPM7PQ.01.09.24.CST  JOPM7PQ.03.03.24.CST  JOPM7PQ.04.25.24.CST  JOPM7PQ.06.17.24.CST  JOPM7PQ.08.09.24.CST  JOPM
JOPM7PQ.01.10.24.CST  JOPM7PQ.03.04.24.CST  JOPM7PQ.04.26.24.CST  JOPM7PQ.06.18.24.CST  JOPM7PQ.08.10.24.CST  JOPM
JOPM7PQ.01.11.24.CST  JOPM7PQ.03.05.24.CST  JOPM7PQ.04.27.24.CST  JOPM7PQ.06.19.24.CST  JOPM7PQ.08.11.24.CST  JOPM
JOPM7PQ.01.12.24.CST  JOPM7PQ.03.06.24.CST  JOPM7PQ.04.28.24.CST  JOPM7PQ.06.20.24.CST  JOPM7PQ.08.12.24.CST  JOPM
JOPM7PQ.01.13.24.CST  JOPM7PQ.03.07.24.CST  JOPM7PQ.04.29.24.CST  JOPM7PQ.06.21.24.CST  JOPM7PQ.08.13.24.CST  JOPM
JOPM7PQ.01.14.24.CST  JOPM7PQ.03.08.24.CST  JOPM7PQ.04.30.24.CST  JOPM7PQ.06.22.24.CST  JOPM7PQ.08.14.24.CST  JOPM
JOPM7PQ.01.15.24.CST  JOPM7PQ.03.09.24.CST  JOPM7PQ.05.01.24.CST  JOPM7PQ.06.23.24.CST  JOPM7PQ.08.15.24.CST  JOPM
JOPM7PQ.01.16.24.CST  JOPM7PQ.03.10.24.CST  JOPM7PQ.05.02.24.CST  JOPM7PQ.06.24.24.CST  JOPM7PQ.08.16.24.CST  JOPM
JOPM7PQ.01.17.24.CST  JOPM7PQ.03.11.24.CST  JOPM7PQ.05.03.24.CST  JOPM7PQ.06.25.24.CST  JOPM7PQ.08.17.24.CST  JOPM
JOPM7PQ.01.18.24.CST  JOPM7PQ.03.12.24.CST  JOPM7PQ.05.04.24.CST  JOPM7PQ.06.26.24.CST  JOPM7PQ.08.18.24.CST  JOPM
JOPM7PQ.01.19.24.CST  JOPM7PQ.03.13.24.CST  JOPM7PQ.05.05.24.CST  JOPM7PQ.06.27.24.CST  JOPM7PQ.08.19.24.CST  JOPM
JOPM7PQ.01.20.24.CST  JOPM7PQ.03.14.24.CST  JOPM7PQ.05.06.24.CST  JOPM7PQ.06.28.24.CST  JOPM7PQ.08.20.24.CST  JOPM
JOPM7PQ.01.21.24.CST  JOPM7PQ.03.15.24.CST  JOPM7PQ.05.07.24.CST  JOPM7PQ.06.29.24.CST  JOPM7PQ.08.21.24.CST  JOPM
JOPM7PQ.01.22.24.CST  JOPM7PQ.03.16.24.CST  JOPM7PQ.05.08.24.CST  JOPM7PQ.06.30.24.CST  JOPM7PQ.08.22.24.CST  JOPM
JOPM7PQ.01.23.24.CST  JOPM7PQ.03.17.24.CST  JOPM7PQ.05.09.24.CST  JOPM7PQ.07.01.24.CST  JOPM7PQ.08.23.24.CST  JOPM
JOPM7PQ.01.24.24.CST  JOPM7PQ.03.18.24.CST  JOPM7PQ.05.10.24.CST  JOPM7PQ.07.02.24.CST  JOPM7PQ.08.24.24.CST  JOPM
JOPM7PQ.01.25.24.CST  JOPM7PQ.03.19.24.CST  JOPM7PQ.05.11.24.CST  JOPM7PQ.07.03.24.CST  JOPM7PQ.08.25.24.CST  JOPM
```

Output simulated flow (HS) files:

<segment_ID>.<ts_ID>.QINE.06.HS

```
/fs/ensembles/projects/nwsrfs/ens/files/demargne/abrfc2005/espts
demargne@lx8-nhdr OB7 dev>  ls J*QINE*HS
JOPM7PQ.JOPM7.QINE.06.HS
```

Hydrologic Hindcaster: Script 2 (a)

- Generates streamflow hindcasts from a set of MAP & MAT hindcasts running OFS FCST ESP function in conditional mode
- Time issue: if MAP & MAT hindcasts in internal time, run ESP with the PQPFTIME technique

FCST input control file for 02/04/1988

Using hindcasts in LST

```
@SETOPT
STARTESP 0204/1988/
WINDOWS(1) 0204/1988/ 0218/1988/
PERMWRIT(1)
HISTSIM(0)
REGULATE(1)
GENTRACE EST
HISTWYRS 1950 1998
ONESEG HUNP1JUN
BLENPREC(1) 0 0 0 0
BLENTEMP(1) 0 0 0 0
ESPADJQ(0)
@COMP ESP
@STOP
```

Carryover date

Forecast period

Conditional sim.

Internal time

Historical water years to use

Using hindcasts in INT

```
@SETOPT
STARTESP 0204/1988/
WINDOWS(1) 0204/1988/ 0218/1988/
PERMWRIT(1)
HISTSIM(0)
REGULATE(1)
PQPFTIME(1)
GENTRACE EST
HISTWYRS 1950 1998
ONESEG HUNP1JUN
BLENPREC(1) 0 0 0 0
BLENTEMP(1) 0 0 0 0
ESPADJQ(0)
@COMP ESP
@STOP
```

Output file: streamflow hindcast file
HUNP1JUN. HUNP1JUN.QINE.06.CS ***saved as***
HUNP1JUN. HUNP1JUN.QINE.06.VS.19880204

Hydrologic Hindcaster: Script 2 (b)

- For a range of hindcasting dates, the ksh script generates streamflow hindcasts from a set of MAP & MAT hindcasts running iteratively OFS FCST ESP function in conditional mode

- User-defined variables:
  - range of hindcasting dates: initial start date, initial end date, time interval between 2 dates, hindcasting stop date
  - time zone (XST)
  - range of historical water years
  - segment/forecast group information: segment option, IDs, paths
  - use_map_mat option to select one source of MAP & MAT hindcasts
  - tokens:
    - ofs fcst input directory, ofs fcst output directory
    - calibration time series directory to run ESP for 1 specific date
    - MAP & MAT hindcasts directory for all the data, $(preadj_outts_dir)
    - ens files directory with carryover data in $(ens_files)/carryover
    - espts directory to save flow hindcasts, $(espts_dir)

- Output:
  - streamflow hindcast (CS) files for range of dates:
    <segment_ID>.<ts_ID>.QINE.06.VS.<year yyyy><month mm><day dd>

Hydrologic Hindcaster: Script 2 (c)

Example for 1 segment

```
#  Set the initial start date
   first_run_start_mon=10
   first_run_start_day=01
   first_run_start_year=2003
#  Set the initial end date
   first_run_end_mon=10
   first_run_end_day=15
   first_run_end_year=2003
#  Set the time interval
   interval=1
#  Set the stop date for running hindcasting
first_round_stop_date=20050930
#  Set the number of years (at least 1) to run hindcasting
   num_years=1
#  Define the time zone code
   time_zone='CST'
#  Define the historical years for generating carryover data
   start_hist_year=1961
   end_hist_year=1998
#  Define the segment or forecast group option
   segment_option=1
#  Define ids, path and names for segment or forecast group and data
#     for segment
   ts_ID=JOPM7
   map_ts_path=abrfcjd
   map_ts_name=jopm7
   mat_ts_path=stens
   mat_ts_name=JOPM7
#     for forecast group
…
#  Set environment variables (tokens)
…
```

Hydrologic Hindcaster: Script 2 (d)

Example for 1 segment

```
#  Loop through the hindcast dates from first start date to stop date
   …
#  for each hindcast date with given start date and end date
  do
#     Create the fcst input file ts_gen
     ts_gen=${fcst_input}/ts_gen
#     Write in input control file
      echo "@SETOPT" > $ts_gen
        echo "STARTESP ${cur_start_date_ofs}" >> $ts_gen
        echo "WINDOWS(1) ${cur_start_date_ofs} ${cur_end_date_ofs}" >> $ts_gen
        echo "PERMWRIT(1)" >> $ts_gen
        echo "HISTSIM(0)" >> $ts_gen
        echo "REGULATE(1)" >> $ts_gen
        if [ $use_map_mat -ge 1 ] ; then
           echo "PQPFTIME(1)" >> $ts_gen
        fi
        echo "GENTRACE ${time_zone}" >> $ts_gen
        echo "HISTWYRS ${start_hist_year} ${end_hist_year}" >> $ts_gen
        if [ $segment_option -ge 1 ] ; then
           echo "ONESEG ${segment_ID}" >> $ts_gen
        else echo "FGROUP ${fgroup_ID}" >> $ts_gen
        fi
        echo "BLENPREC(1) 0 0 0 0" >> $ts_gen
        echo "BLENTEMP(1) 0 0 0 0" >> $ts_gen
        echo "ESPADJQ(0)" >> $ts_gen
        echo "@COMP ESP" >> $ts_gen
        echo "@STOP" >> $ts_gen
      fi
      echo "@COMP ESP" >> $co_gen
      echo "@STOP" >> $co_gen
       …
```

Hydrologic Hindcaster: Script 2 (d) (cont')

```
…
#     For MAP and MAT hindcasts with date stamp, copy files for the run date in the input directory
#     for segment
        if [ $use_map_mat -eq 2 ] ; then
             rm -f ${calb_area_ts_dir}/${map_ts_path}/${map_ts_name}.MAP06
             rm -f ${calb_area_ts_dir}/${mat_ts_path}/${mat_ts_name}.MAT
             cp
${preadj_outts_dir}/${map_ts_path}/${map_ts_name}/${new_start_yy}${new_start_mm}${new_start_dd}${map_ts_name}.MAP06
${calb_area_ts_dir}/${map_ts_path}/${map_ts_name}.MAP06
             cp
${preadj_outts_dir}/${mat_ts_path}/${new_start_yy}${new_start_mm}${new_start_dd}${mat_ts_name}.MAT
${calb_area_ts_dir}/${mat_ts_path}/${mat_ts_name}.MAT
          fi
#     for forecast group
…
#     Run the fcst program
      ofs -p fcst -i ts_gen -o ts_gen
#     Remove output file in the $(fcst_output) directory
      rm -f ${fcst_output}/fcst_*
      rm -f ${fcst_output}/ts_gen.*
#     Archive the *QINE*.CS file with date stamp in the $(espts_dir)
#     for segment
        if [ $segment_option -ge 1 ] ; then
           mv -f ${espts_dir}/${segment_ID}.${ts_ID}.QINE.06.CS
                 ${espts_dir}/${segment_ID}.${ts_ID}.QINE.06.VS.${new_start_yy}${new_start_mm}${new_start_dd}
        fi
#     for forecast group
        …
#     Delete the *SSTG*.CS file
        rm -f ${espts_dir}/*.SSTG.06.CS
#     Compute start date and end date for the next run
      …
  done
```

Hydrologic Hindcaster: Script 2 (e)

Forcing input hindcast files:

<year><month><day>.<ts_ID>.MAP06

```
20040101jopm7.MAP06   20040216jopm7.MAP06   20
20040102jopm7.MAP06   20040217jopm7.MAP06   20
20040103jopm7.MAP06   20040218jopm7.MAP06   20
20040104jopm7.MAP06   20040219jopm7.MAP06   20
20040105jopm7.MAP06   20040220jopm7.MAP06   20
20040106jopm7.MAP06   20040221jopm7.MAP06   20
20040107jopm7.MAP06   20040222jopm7.MAP06   20
20040108jopm7.MAP06   20040223jopm7.MAP06   20
20040109jopm7.MAP06   20040224jopm7.MAP06   20
20040110jopm7.MAP06   20040225jopm7.MAP06   20
20040111jopm7.MAP06   20040226jopm7.MAP06   20
20040112jopm7.MAP06   20040227jopm7.MAP06   20
```

<year><month><day>.<ts_ID>.MAT

```
20040101JOPM7.MAT   20040211JOPM7.MAT   20
20040102JOPM7.MAT   20040212JOPM7.MAT   20
20040103JOPM7.MAT   20040213JOPM7.MAT   20
20040104JOPM7.MAT   20040214JOPM7.MAT   20
20040105JOPM7.MAT   20040215JOPM7.MAT   20
20040106JOPM7.MAT   20040216JOPM7.MAT   20
20040107JOPM7.MAT   20040217JOPM7.MAT   20
20040108JOPM7.MAT   20040218JOPM7.MAT   20
20040109JOPM7.MAT   20040219JOPM7.MAT   20
20040110JOPM7.MAT   20040220JOPM7.MAT   20
20040111JOPM7.MAT   20040221JOPM7.MAT   20
20040112JOPM7.MAT   20040222JOPM7.MAT   20
```

Output flow hindcast files (binary):

<segment_ID>.<ts_ID>.QINE.06.VS.<year><month><day>

```
/fs/ensembles/projects/nwsrfs/ens/files/demargne/abrfc2005/espts/verif_rfc_gfs1
demargne@lx8-nhdr OB7 dev> ls J*2004*
JOPM7PQ.JOPM7.QINE.06.VS.20040101  JOPM7PQ.JOPM7.QINE.06.VS.20040403  JOPM7PQ.JOPM7.QINE.06.VS.20040703  JOPM
JOPM7PQ.JOPM7.QINE.06.VS.20040102  JOPM7PQ.JOPM7.QINE.06.VS.20040404  JOPM7PQ.JOPM7.QINE.06.VS.20040704  JOPM
JOPM7PQ.JOPM7.QINE.06.VS.20040103  JOPM7PQ.JOPM7.QINE.06.VS.20040405  JOPM7PQ.JOPM7.QINE.06.VS.20040705  JOPM
JOPM7PQ.JOPM7.QINE.06.VS.20040104  JOPM7PQ.JOPM7.QINE.06.VS.20040406  JOPM7PQ.JOPM7.QINE.06.VS.20040706  JOPM
JOPM7PQ.JOPM7.QINE.06.VS.20040105  JOPM7PQ.JOPM7.QINE.06.VS.20040407  JOPM7PQ.JOPM7.QINE.06.VS.20040707  JOPM
JOPM7PQ.JOPM7.QINE.06.VS.20040106  JOPM7PQ.JOPM7.QINE.06.VS.20040408  JOPM7PQ.JOPM7.QINE.06.VS.20040708  JOPM
JOPM7PQ.JOPM7.QINE.06.VS.20040107  JOPM7PQ.JOPM7.QINE.06.VS.20040409  JOPM7PQ.JOPM7.QINE.06.VS.20040709  JOPM
JOPM7PQ.JOPM7.QINE.06.VS.20040108  JOPM7PQ.JOPM7.QINE.06.VS.20040410  JOPM7PQ.JOPM7.QINE.06.VS.20040710  JOPM
JOPM7PQ.JOPM7.QINE.06.VS.20040109  JOPM7PQ.JOPM7.QINE.06.VS.20040411  JOPM7PQ.JOPM7.QINE.06.VS.20040711  JOPM
JOPM7PQ.JOPM7.QINE.06.VS.20040110  JOPM7PQ.JOPM7.QINE.06.VS.20040412  JOPM7PQ.JOPM7.QINE.06.VS.20040712  JOPM
JOPM7PQ.JOPM7.QINE.06.VS.20040111  JOPM7PQ.JOPM7.QINE.06.VS.20040413  JOPM7PQ.JOPM7.QINE.06.VS.20040713  JOPM
```

Hydrologic Hindcaster: Script 2 (f)

Examples of forcing input hindcast files:

20040101jopm7.MAP06

```
$  IDENTIFIER=jopm7   DESCRIPTION=   jopm7
$  PERIOD OF RECORD=  1/1961 THRU   1/1997
$  SYMBOL FOR MISSING DATA=-999.00   SYMBOL FOR ACCUMULATED DATA=-998.00
$  TYPE=MAP    UNITS=IN     DIMENSIONS=L      DATA TIME INTERVAL= 6 HOURS
$  OUTPUT FORMAT=(3A4,2I2,I4,4F12.3)
PQPF          MAP  L    IN    6          jopm7                  jopm7
 1  1961  1   1997  4   F12.3
            161   1       0.000       0.000       0.000       0.000
            161   2       0.000       0.000       0.000       0.000
            161   3       0.000       0.000       0.000       0.000
            161   4       0.000       0.000       0.000       0.000
            161   5       0.000       0.000       0.000       0.000
            161   6       0.000       0.000       0.000       0.000
            161   7       0.000       0.000       0.000       0.000
            161   8       0.000       0.000       0.000       0.000
            161   9       0.000       0.000       0.000       0.000
            161  10       0.000       0.000       0.000       0.000
            161  11       0.000       0.000       0.000       0.000
            161  12       0.000       0.000       0.000       0.000
            161  13       0.000       0.000       0.000       0.001
            161  14       0.000       0.001       0.000       0.000
            161  15    -999.000    -999.000    -999.000    -999.000
```

20040101JOPM7.MAT

```
$  IDENTIFIER=JOPM7   DESCRIPTION=SHOAL CRK
$  PERIOD OF RECORD= 1/1961 THRU  1/1998
$  SYMBOL FOR MISSING DATA=-999.00   SYMBOL FOR ACCUMULATED DATA=-998.00
$  TYPE=MAT    UNITS=DEGF   DIMENSIONS=TEMP   DATA TIME INTERVAL= 6 HOURS
$  OUTPUT FORMAT=(3A4,2I2,I4,4f12.3)
PQTF          MAT  TEMP DEGF  6          JOPM7   SHOAL CRK
 1  1961  1   1998  4   f12.3
            161   1      32.883      38.795      22.386      22.213
            161   2      35.389      47.983      34.605      14.756
            161   3      43.226      52.567      43.303      28.150
            161   4      49.083      54.568      37.240      38.813
            161   5      44.952      54.494      40.380      29.206
            161   6      43.413      48.855      32.114      33.682
            161   7      37.901      45.753      27.955      24.347
            161   8      38.860      50.113      30.001      19.635
            161   9      40.517      52.413      32.825      20.529
            161  10      44.456      56.543      32.689      23.570
            161  11      44.763      59.015      40.940      21.492
            161  12      48.021      58.031      49.105      32.302
            161  13      52.294      56.140      39.672      44.749
            161  14      34.030      35.822      32.542      32.078
            161  15    -999.000    -999.000    -999.000    -999.000
```

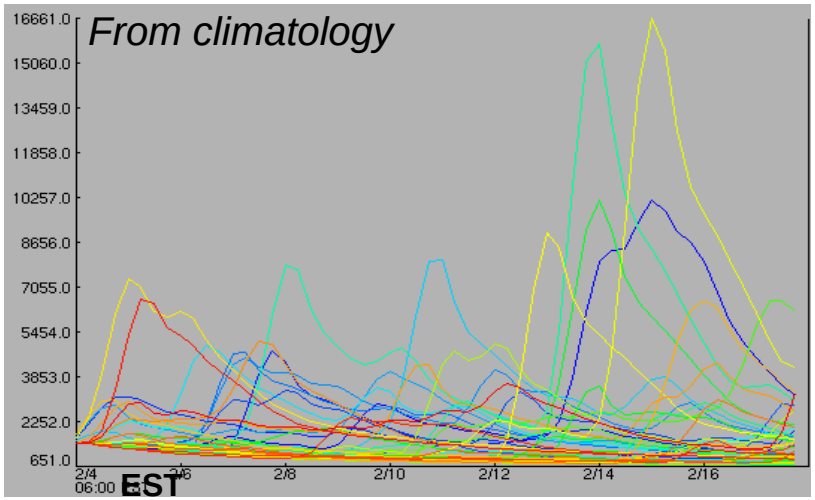
Example of ascii flow hindcast files (print_ts output):

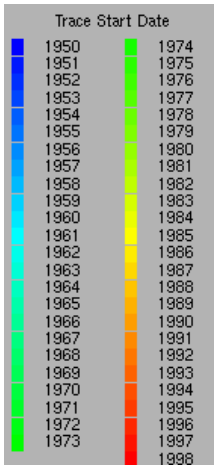
ts.JOPM7PQ.JOPM7.QINE.06.VS.20040101

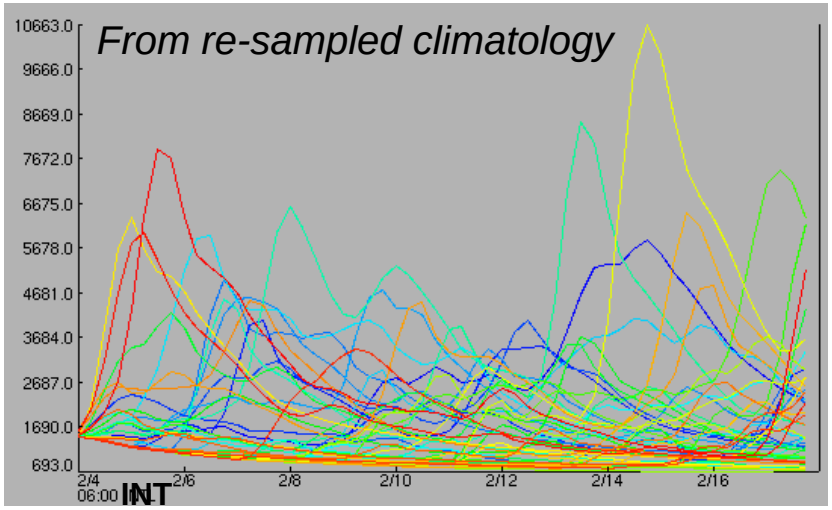
```
PRINTING OUT TS HEADER INFORMATION
    THE TIME SERIES ID IS: JOPM7
    THE DATA TYPE IS: QINE
    THE START DATE IS:  1/ 1/1961
    THE TIME STEP IS:  6
    THE CARRYOVER JUL DAY (ijdlst): 37985
    THE CARRYOVER HOUR (ihlst): 24
    THE FORECAST ENDING JUL DAY (ljdlst): 37999
    THE FORECAST ENDING HOUR (lhlst): 24
    THE START JUL DAY (idarun): 22280
    THE START HOUR (ihlst): 24
    THE END JUL DAY (ldarun): 35443
    THE END HOUR (lhlst): 24
    THE NUMBER OF CONDITIONAL MONTHS: 1

 1/ 1/1961 -->  1.005912    0.994390    0.982677    0.971347
 1/ 2/1961 -->  0.961880    0.952660    0.942509    0.932322
 1/ 3/1961 -->  0.921248    0.909900    0.898942    0.888097
 1/ 4/1961 -->  0.876243    0.864515    0.853765    0.843329
 1/ 5/1961 -->  0.832090    0.820892    0.810487    0.800341
 1/ 6/1961 -->  0.793741    0.788430    0.782035    0.775781
 1/ 7/1961 -->  0.770284    0.764104    0.756702    0.748997
 1/ 8/1961 -->  0.738663    0.727966    0.718756    0.709827
 1/ 9/1961 -->  0.699128    0.688606    0.679725    0.671279
 1/10/1961 -->  0.661388    0.651494    0.642834    0.634488
 1/11/1961 -->  0.627242    0.620724    0.614318    0.608149
 1/12/1961 -->  0.604315    0.600790    0.595976    0.591020
 1/13/1961 -->  0.588298    0.585770    0.581775    0.577562
 1/14/1961 -->  0.577397    0.577804    0.575799    0.573441
 1/15/1961 -->  -999.000000 -999.000000 -999.000000 -999.000000
```

Hydrologic Hindcaster: Output

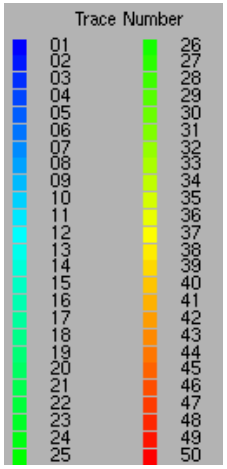
- Using MAP & MAT hindcasts from a specific *preadj_outts_dir* directory, generate streamflow hindcasts in the corresponding *espts_dir* directory

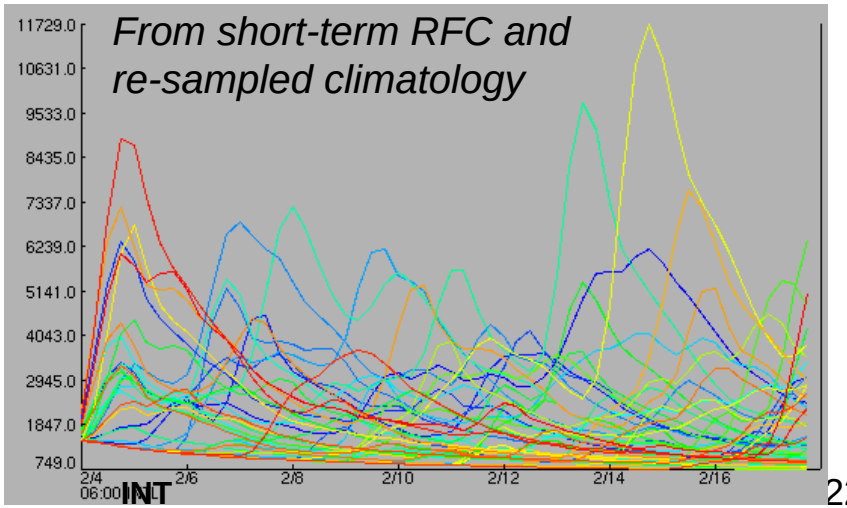






Streamflow ensembles (cfs), Huntingdon, MARFC





Link with Ensemble Verification

- Running Ensemble Verification System (EVS) with hindcasts (ascii files) from a specific directory

Methodology	*Flow hindcast directory*
Climatology	$(ens_files)/espts/climato
Re-sampled climatology	$(ens_files)/espts/pre_climato
Short-term RFC	$(ens_files)/espts/pre_short_rfc
Short-term GFS	$(ens_files)/espts/pre_short_gfs
Short-term RFC & GFS	$(ens_files)/espts/pre_short_rfcgfs

- Step 1: run converter script based on print_ts routine to convert binary flow hindcasts <segment_ID>.<ts_ID>.QINE.06.VS.yyyymmdd into text files ts.<segment_ID>.<ts_ID>.QINE.06.VS.yyyymmdd

- Step 2: run verification programs to compute verification statistics

  Briers Score (BS) statistics, Rank Probability Score (RPS) statistics, Reliability diagrams, Relative Operating Characteristic diagram, Scatter plots, deterministic measures

Hindcaster: Data Issues

Required data for ensemble generation and verification:

- Precipitation:
  - MAP observations, up to present, datacard format
  - HPC/RFC forecasts and/or GFS forecasts, up to present
- Temperature :
  - MAT observations, up to present, datacard format
  - HPC/RFC forecasts and/or GFS forecasts for TMax and TMin, up to present
- Other inputs (MAPE, PTPE, QME, etc.) up to present
- Streamflow:
  - Observations, up to present, datacard format

Thank you