Climate Change Modeling in Lake Mead

Lake Mead Ecosystem Monitoring Workgroup
Las Vegas, NV
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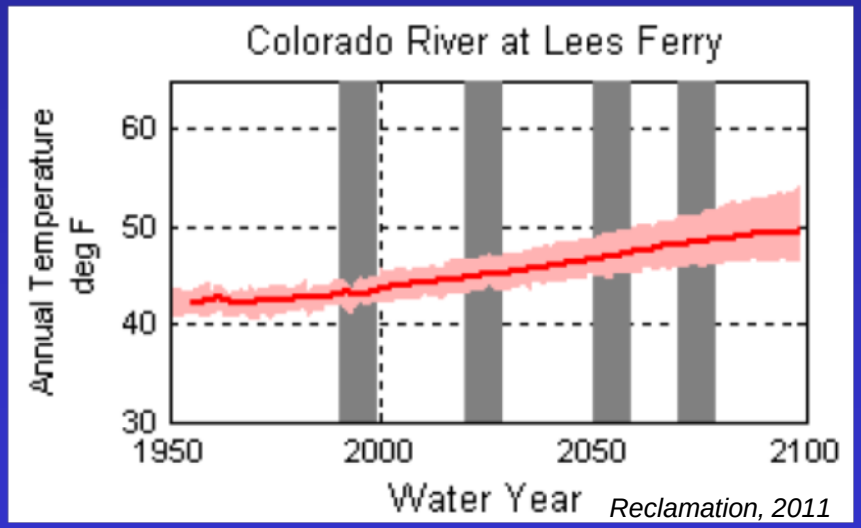
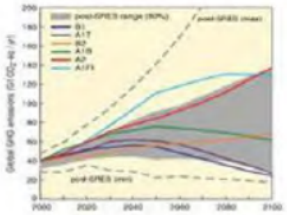


Reclamation, 2011

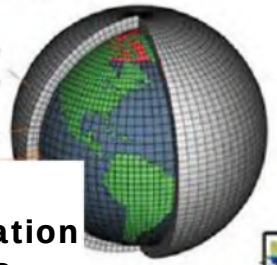
This work was sponsored by U.S. Bureau of Reclamation through WaterSMART agreement number R11AP81452

Climate Change Modeling



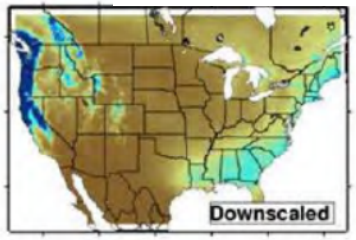
Emission Scenarios (3 scenarios: A2, A1b, B1)

RECLAMATION
USGS
Santa Clara University
CLIMATE CENTRAL
SCRIPPS INSTITUTION OF OCEANOGRAPHY

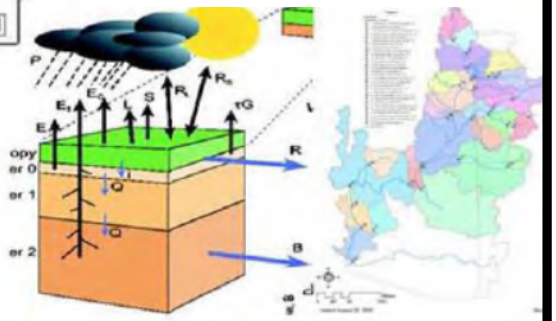


Global Circulation Models (16 GCMs)

Bias Correction & Spatial Downscaling (112 downscaled projections through 2099)



Hydrologic Modeling (112 projections through 2099)



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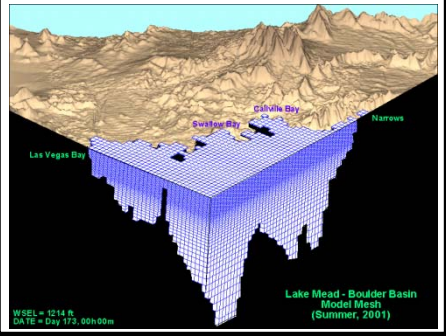
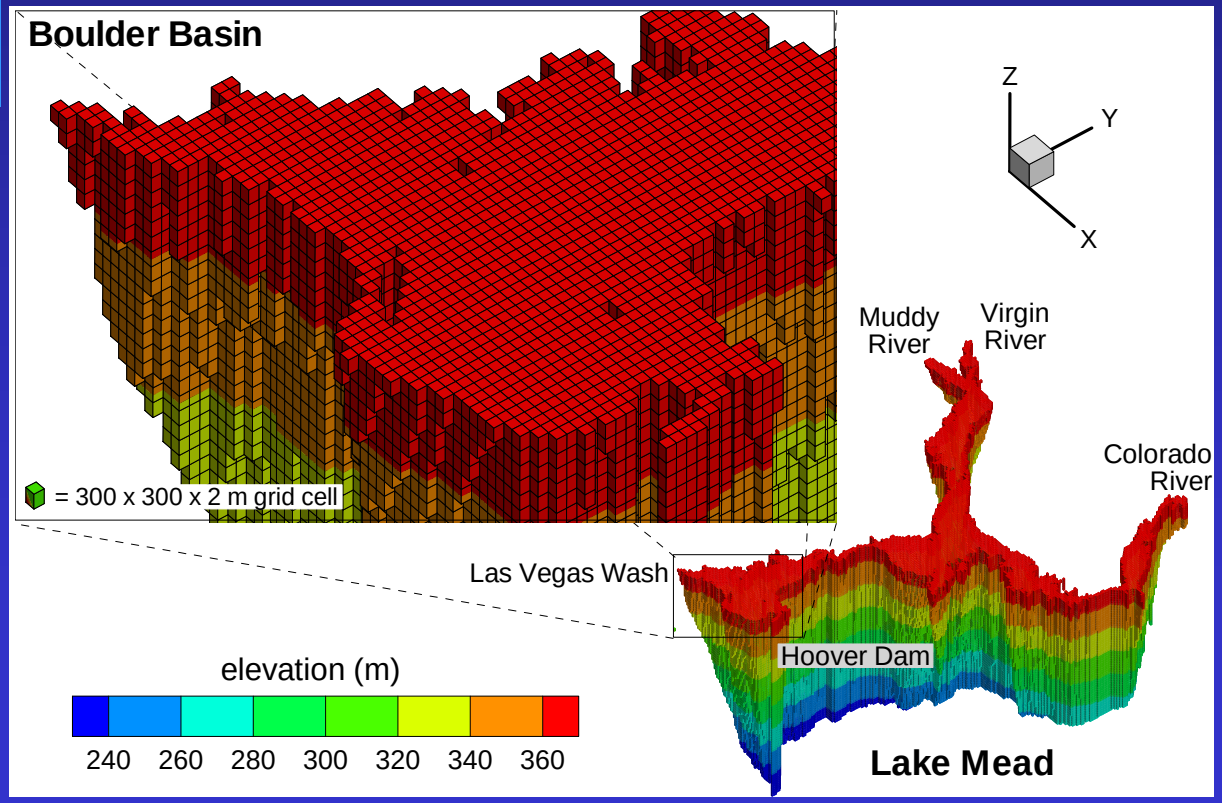
Lake Mead Water Quality Modeling:
(decadal medians, 90th percentiles)



Adapted from Colorado River Basin Water Supply and Demand Study, Reclamation, 2012

Lake Mead Model

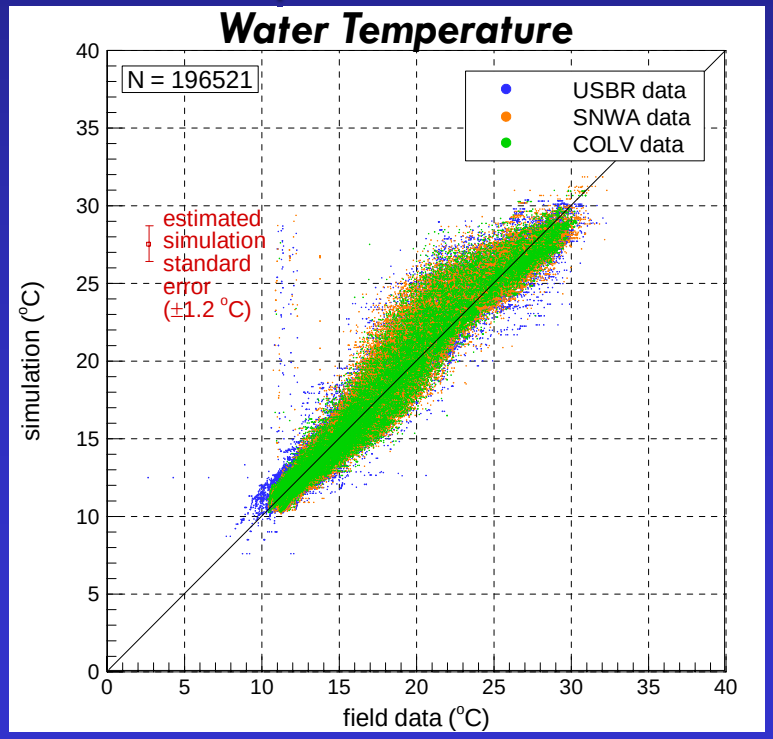
- Lake Mead Model (LMM) uses ELCOM/CAEDYM codes
- ELCOM
  - 3-D hydrodynamic model, stratification, wind mixing, temperature, salinity, conservative tracers
- CAEDYM
  - Water quality module, algae (chl-a), nutrients, TOC, DO, pH

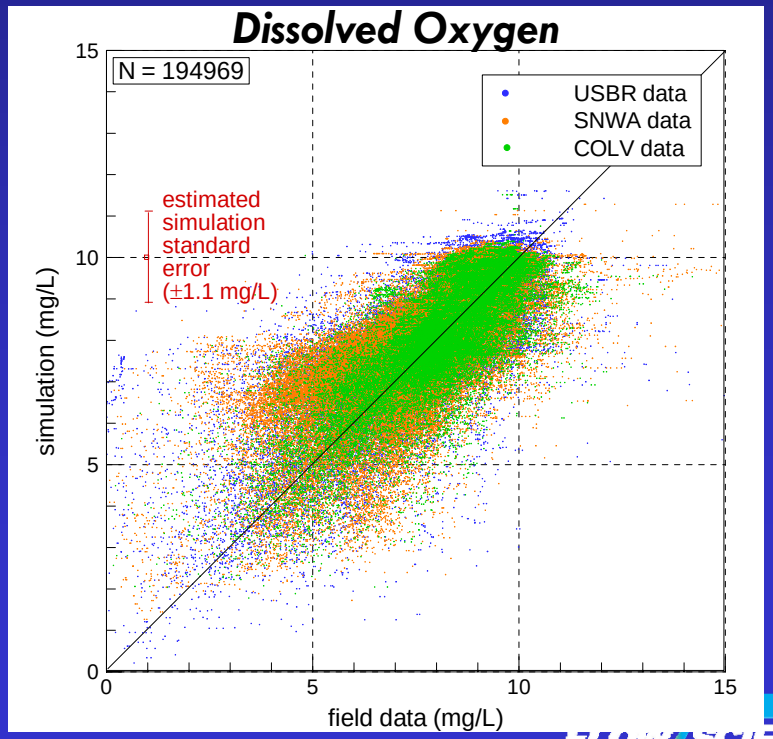


- ELCOM/CAEDYM developed by Centre for Water Research (UWA)
- LMM Funded by Clean Water Coalition, SNWA and National Park Service

Lake Mead Model Calibration

- **Parameters include:**
  - Temperature, salinity, conductivity, bromide, perchlorate
  - Algae (chl-a), TOC, phosphorus, nitrogen, DO, pH
- **LMM calibrated for years 2000 – 2008**
  - Comparisons with field data at 20+ locations





Adjustment of LMM inputs

- **Air temperature**
- **Inflow water temperature**

Primary drivers
CMIP3 projections

- **Inflow rates**
- **WSEL**

Difficult to quantify. Upstream inflows are controlled. Uncertainty Examined extremes.

- **Inflow water quality**

Difficult to quantify.
Not considered.

- **Wind speed**
- **Rainfall**

Climate projections indicate generally small changes.
Not considered.

- **Relative humidity**
- **Solar radiation / cloud cover**

Climate projections did not provide direct information.
Not considered.

Simulations

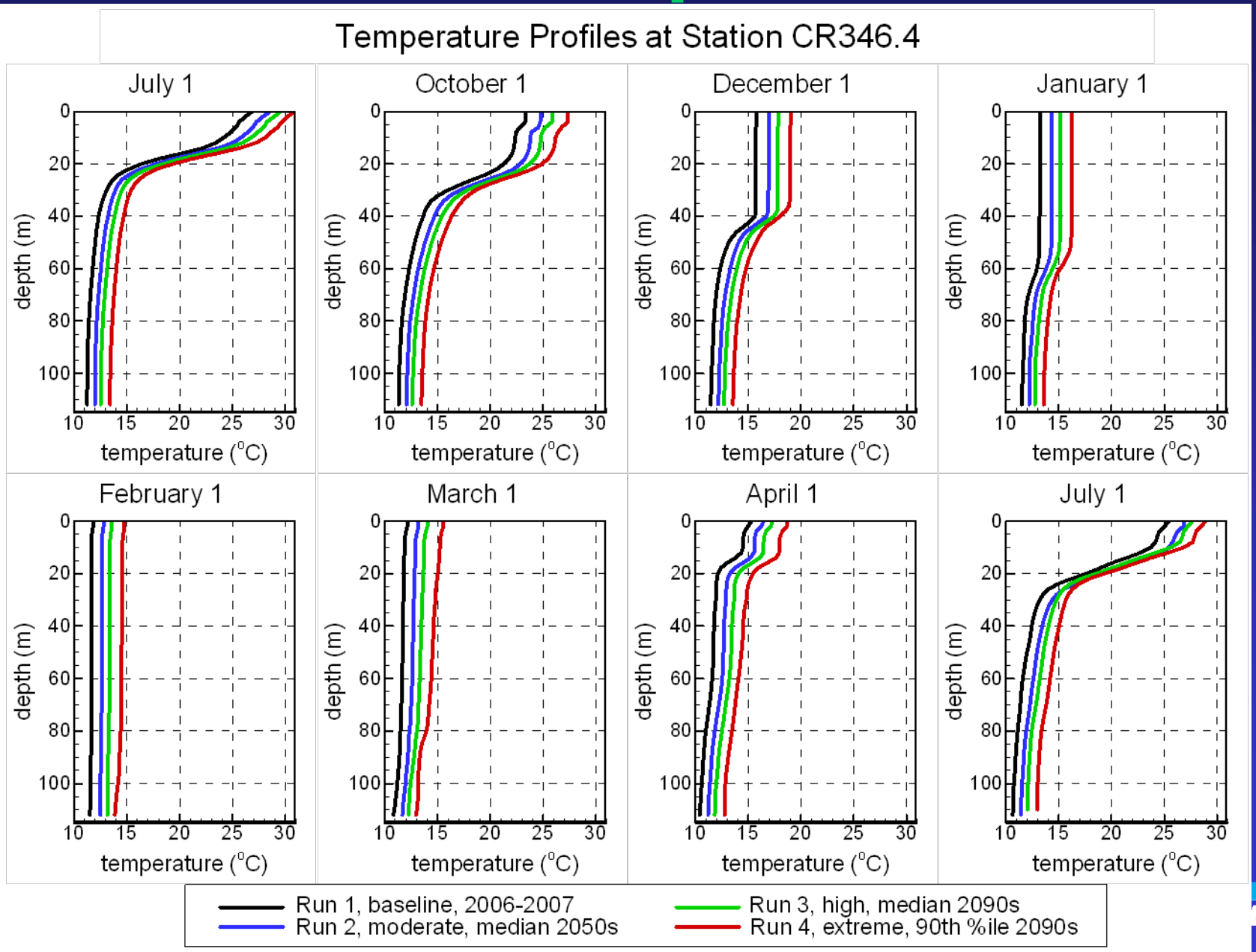
Run	Purpose	Time period / projection	Change in average air temperature (C)	Colorado River inflow (MAF/yr)	Initial WSEL (feet)	Effluent flow rate (MGD)[3]
Run 1	**baseline**	**2006 – 2007**	**0.0**	**9.23**	**1,100**	**200**
Run 2	**moderate warming**	**median[1] 2050s**	**2.0**	**9.23**	**1,100**	**298**
Run 3	**high warming**	**median[1] 2090s**	**3.2**	**9.23**	**1,100**	**441**
Run 4	**extreme warming**	**90th percentile[2] 2090s**	**5.4**	**9.23**	**1,100**	**441**
Run 5	**low CR inflow**	**median[1] 2090s**	**3.2**	**7.00**	**1,100**	**441**
Run 6	**high CR inflow**	**median[1] 2090s**	**3.2**	**14.78**	**1,100**	**441**
Run 7	**low WSEL**	**median[1] 2090s**	**3.2**	**9.23**	**1,040**	**441**
Run 8	**extreme low WSEL**	**median[1] 2090s**	**3.2**	**9.23**	**925**	**441**
Run 9	**2nd algal group (high warming)**	**median[1] 2090s**	**3.2**	**9.23**	**1,100**	**441**
Run 10	**2nd algal group (extreme warm.)**	**90th percentile[2] 2090s**	**5.4**	**9.23**	**1,100**	**441**

1. Median of the 112 projections.
2. 90th percentile of the 112 projections.
3. Effluent flow rate varies, but effluent phosphorus and nitrogen loads are constant (TP load = 225 lbs/day)

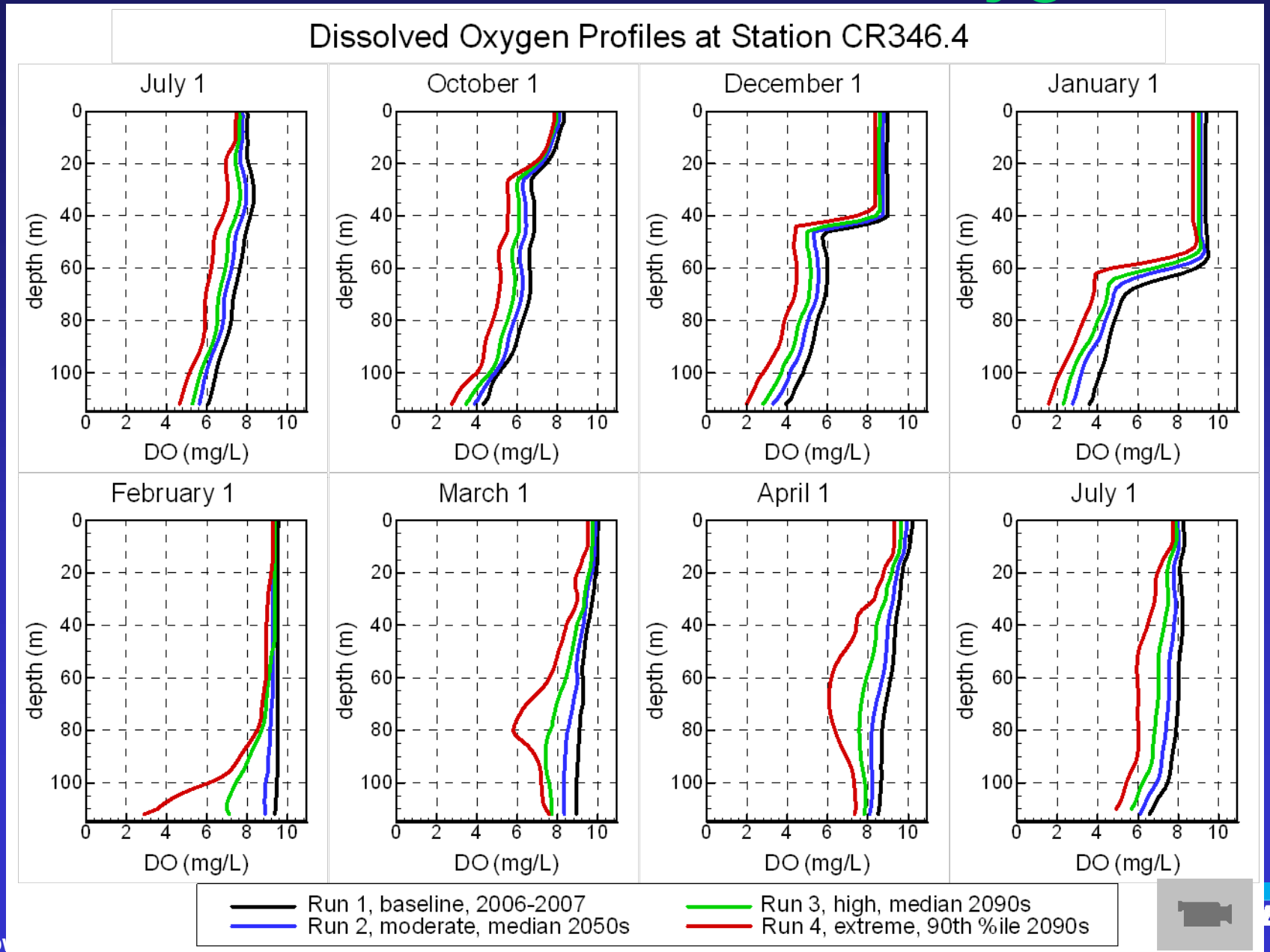
Results

- **Stratification**
  - Temperature
  - Dissolved Oxygen
- **"Hoover Dam effect"**
  - Withdrawals from epilimnion
- **WSEL**
  - SNWA Intake #3
- **Algae (Chlorophyll a)**

Stratification – Temperature



Stratification – Dissolved Oxygen



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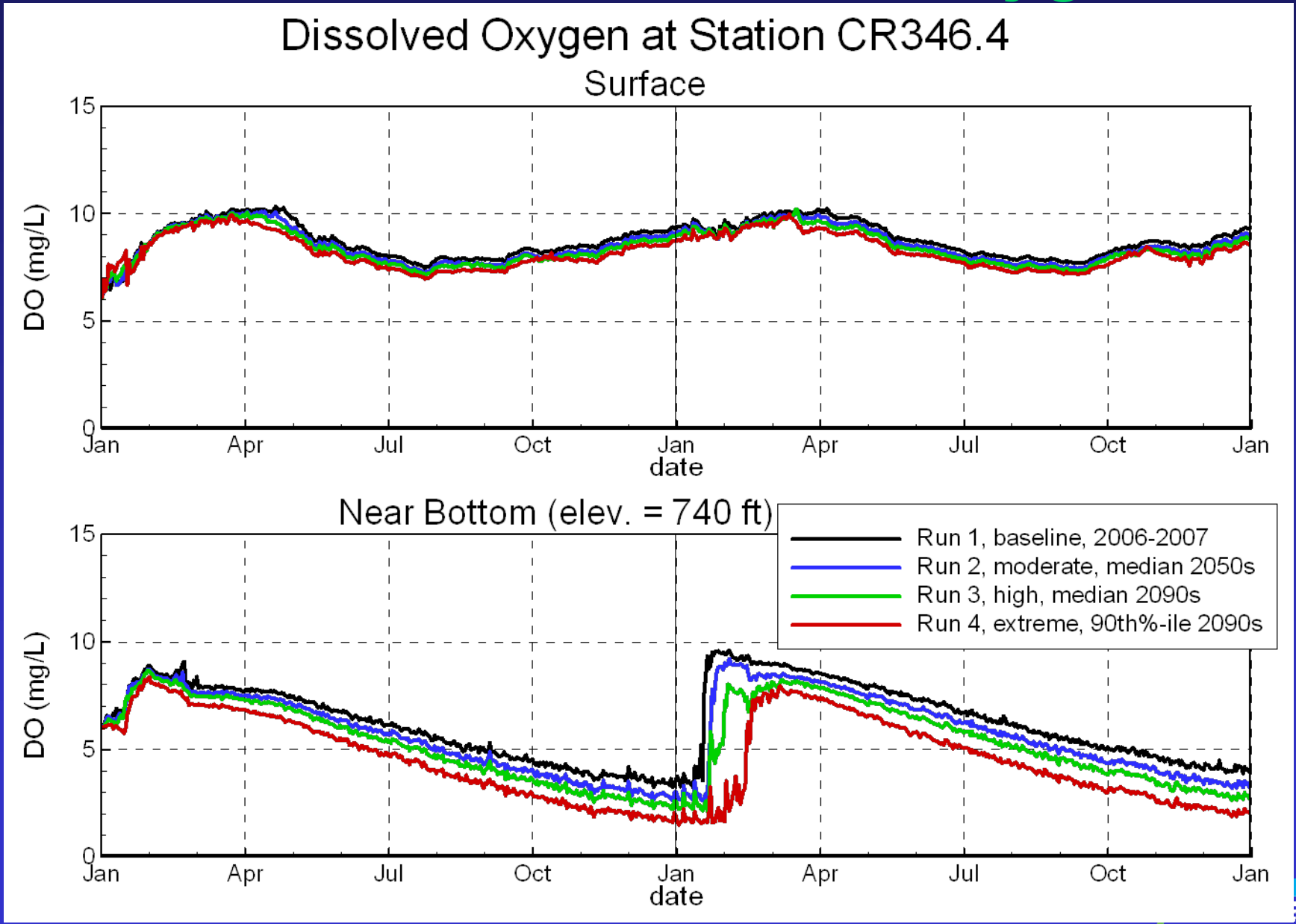
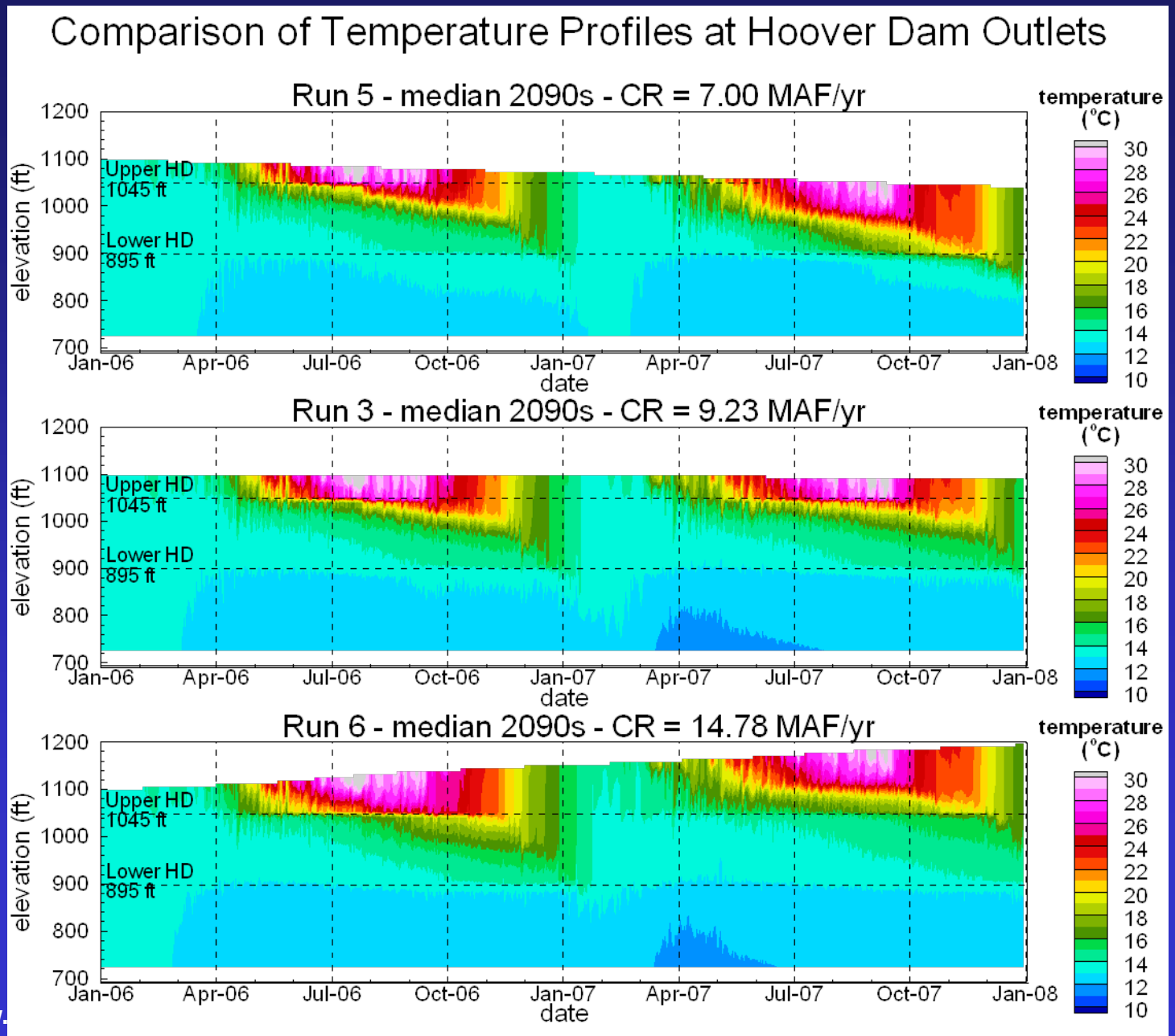


" Hoover Dam Effect "



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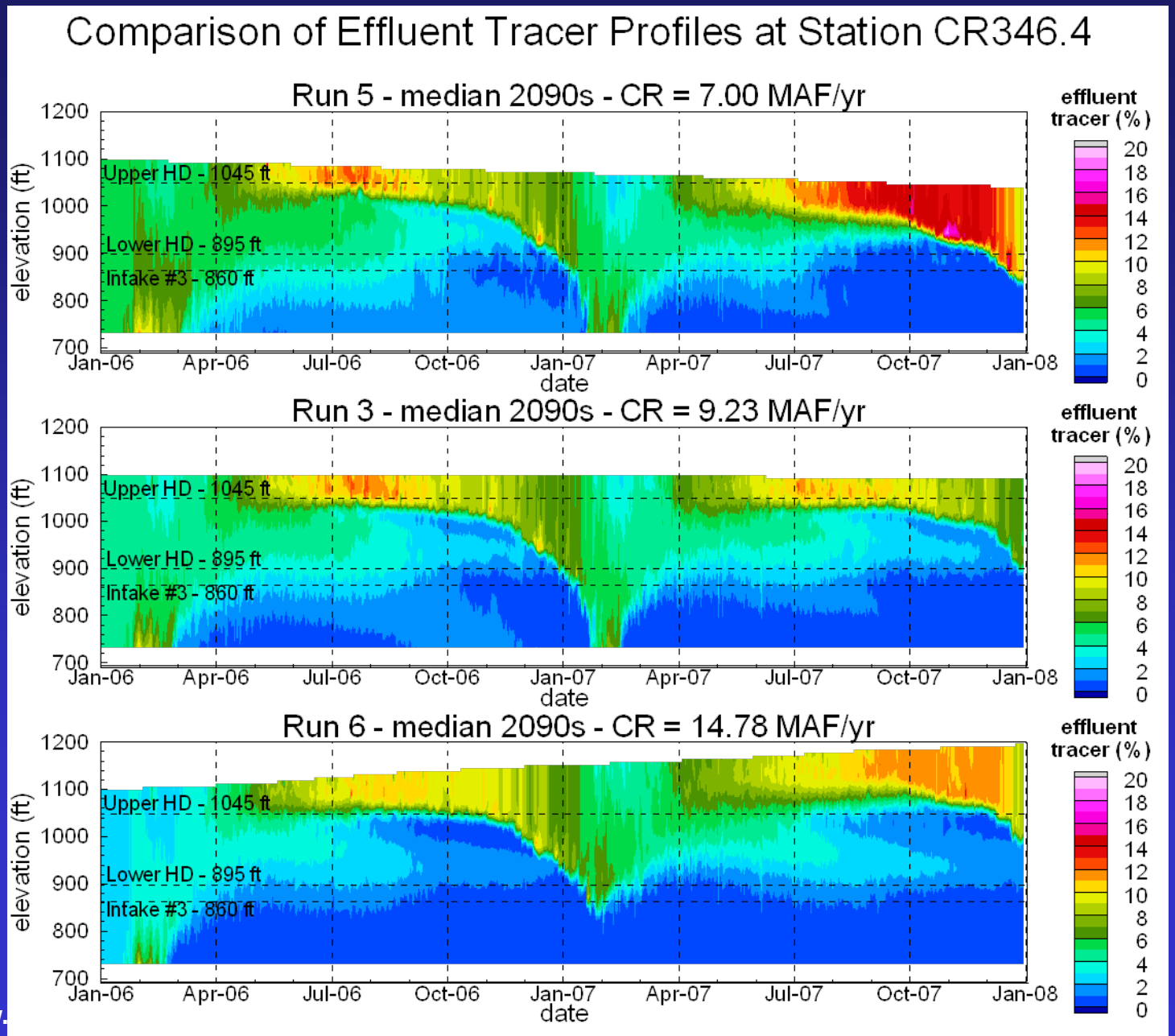

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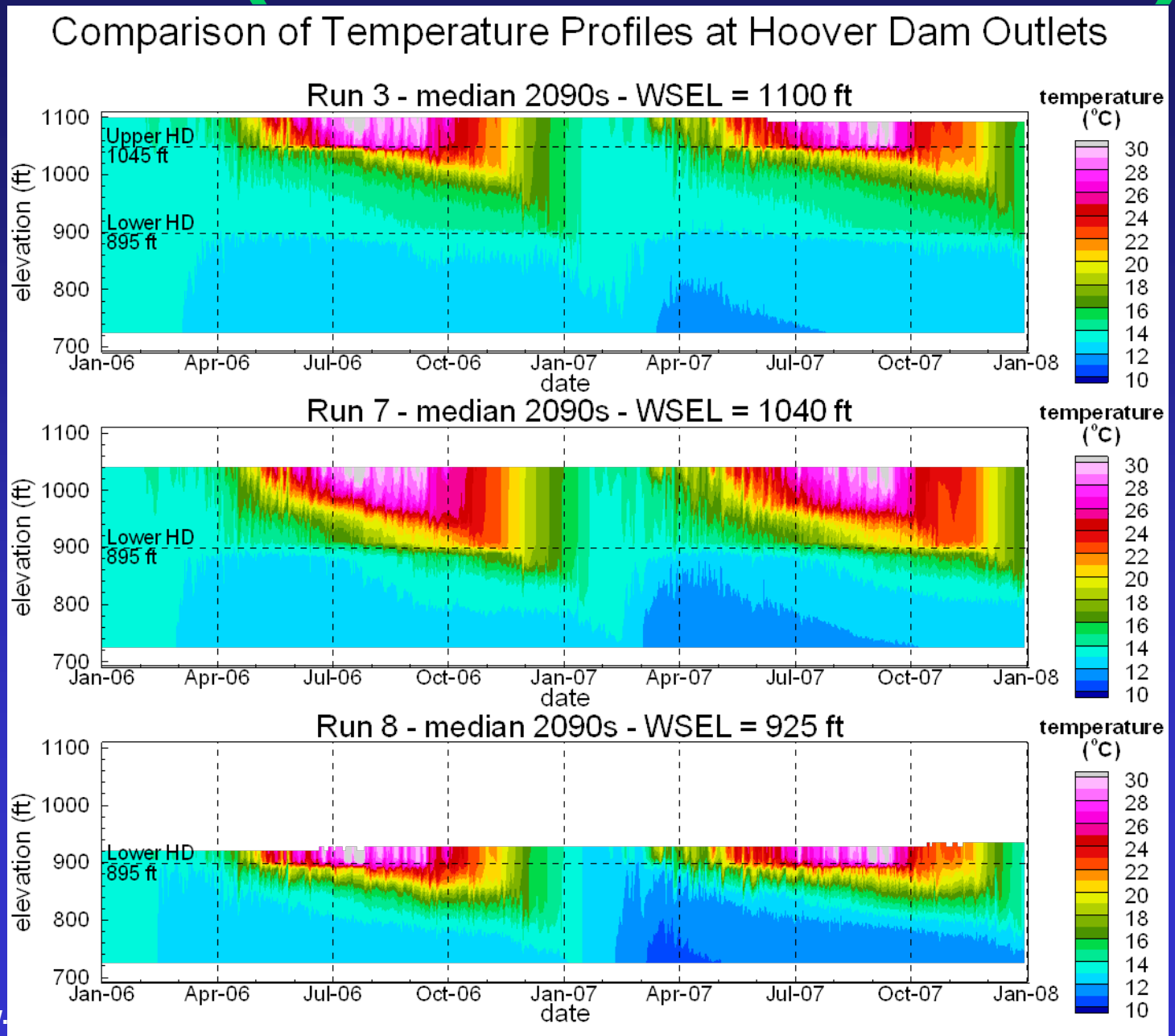
WSEL (and Hoover Dam Effect)



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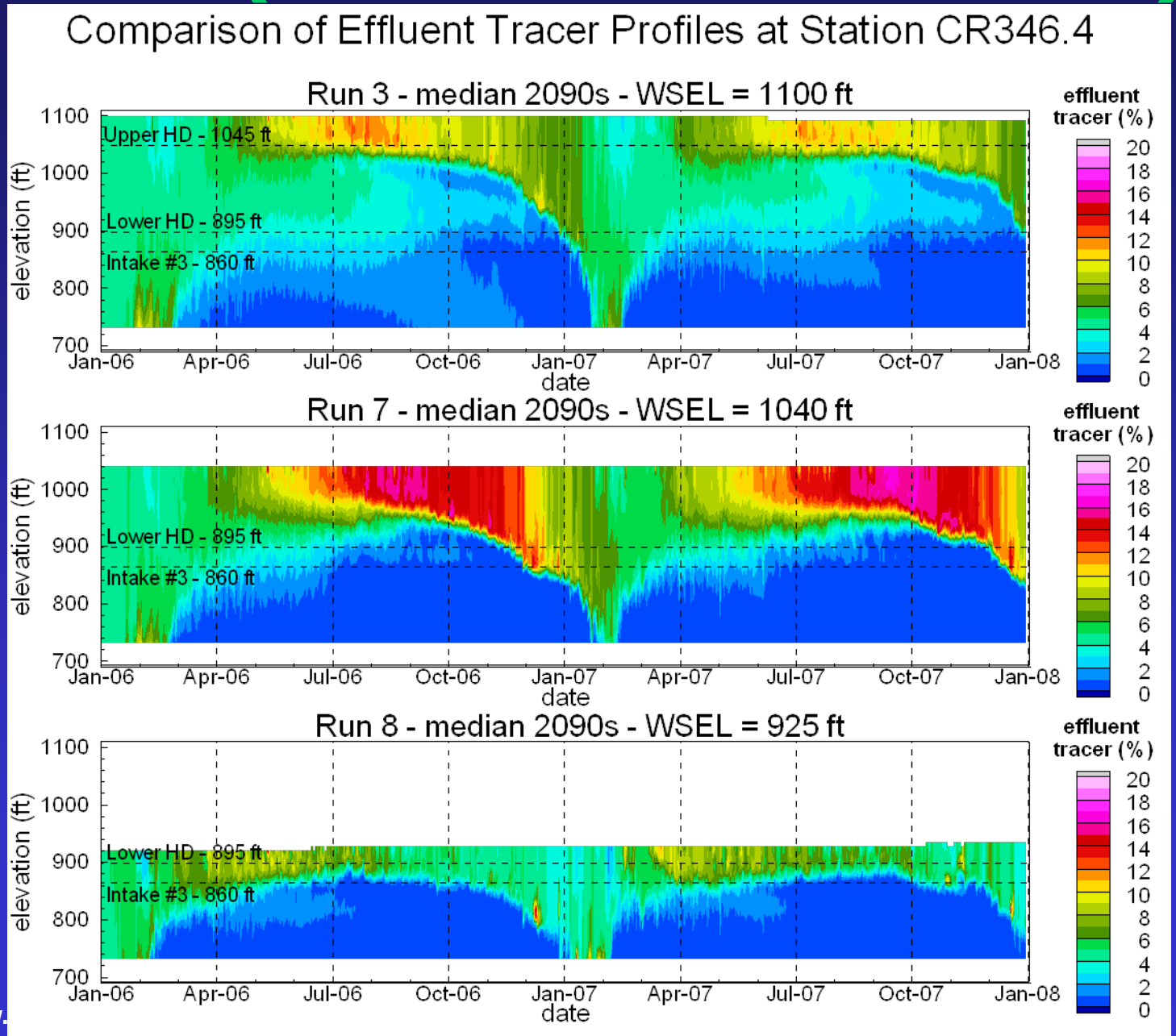

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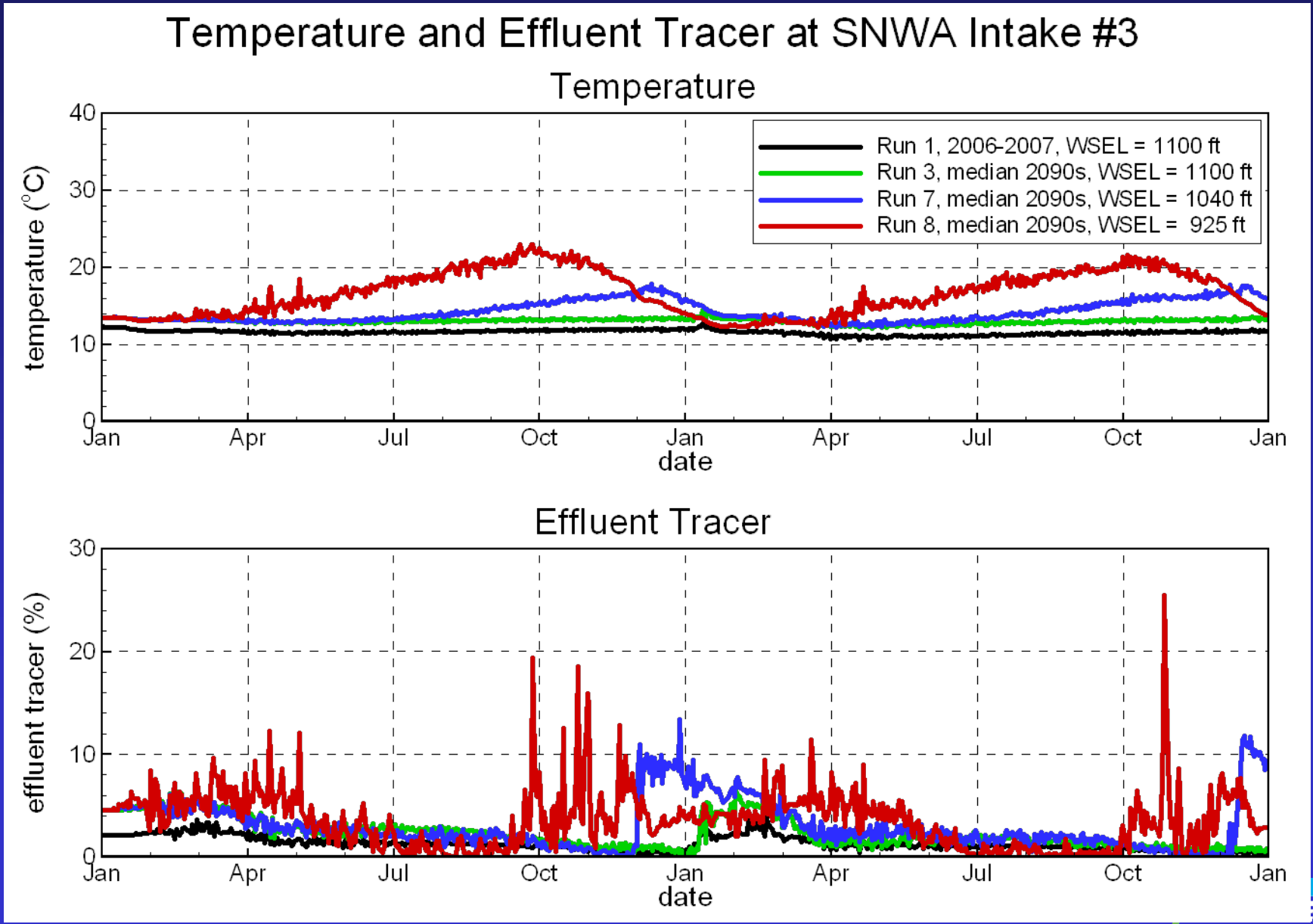
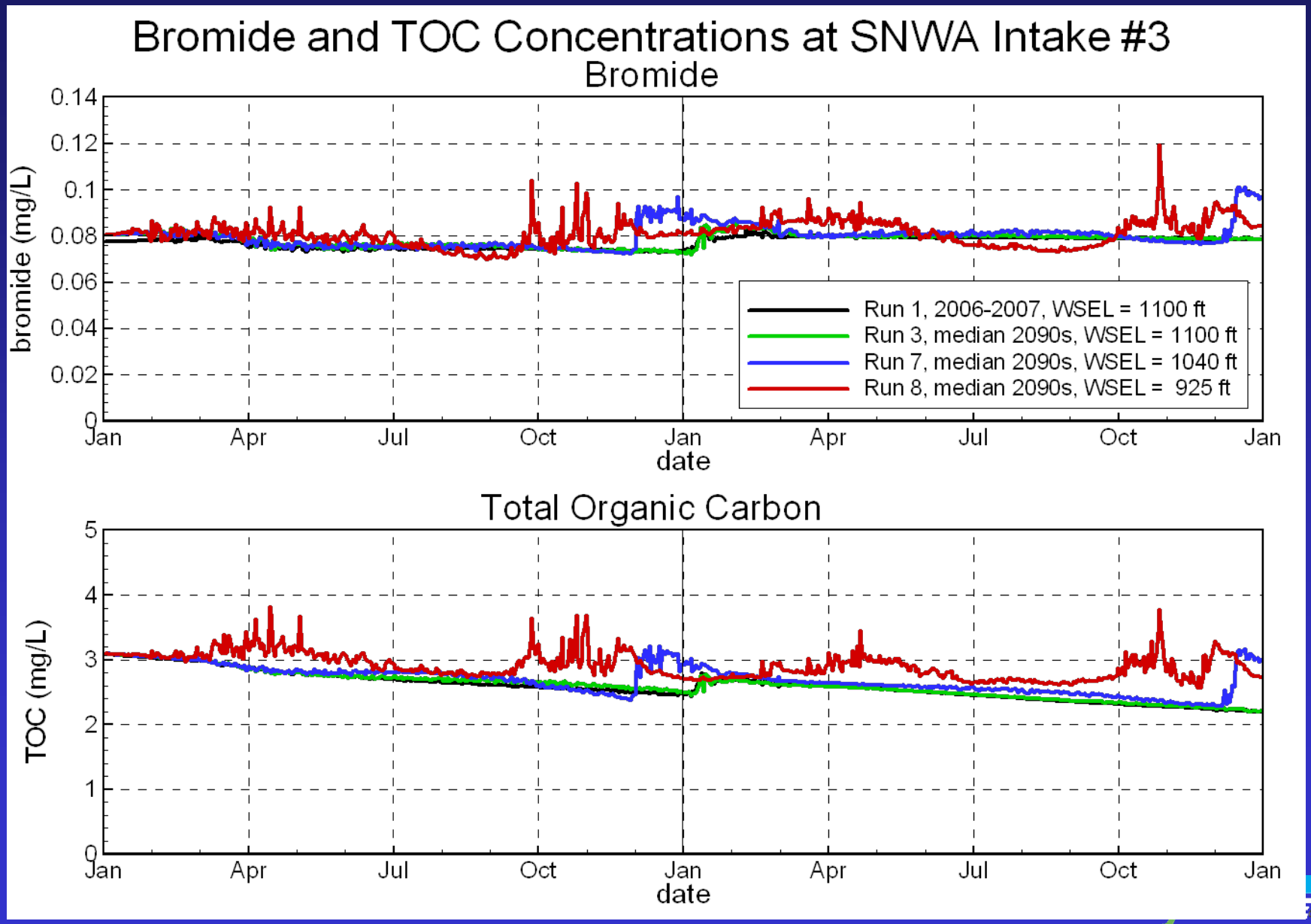
SNWA Intake #3

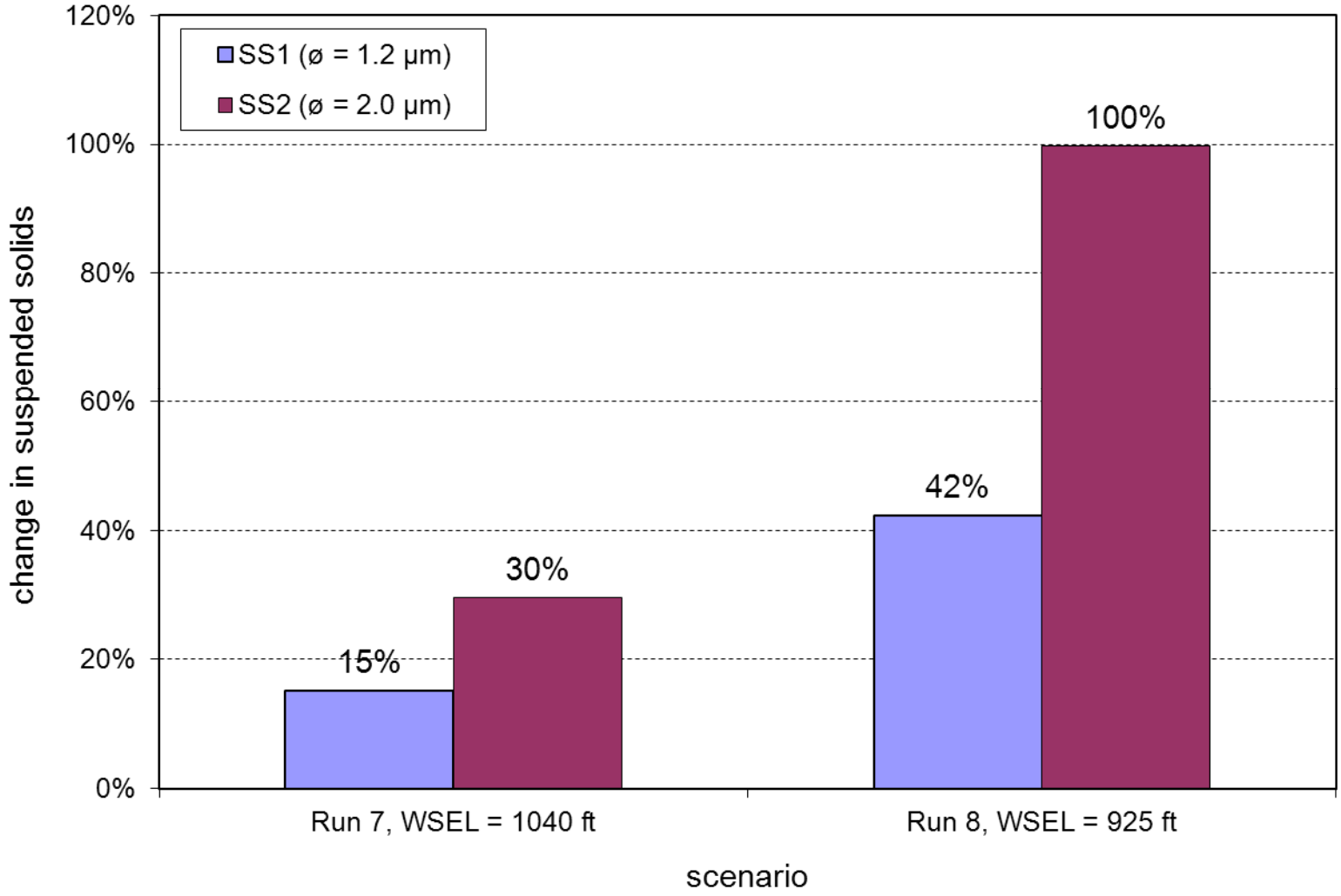


SNWA Intake #3



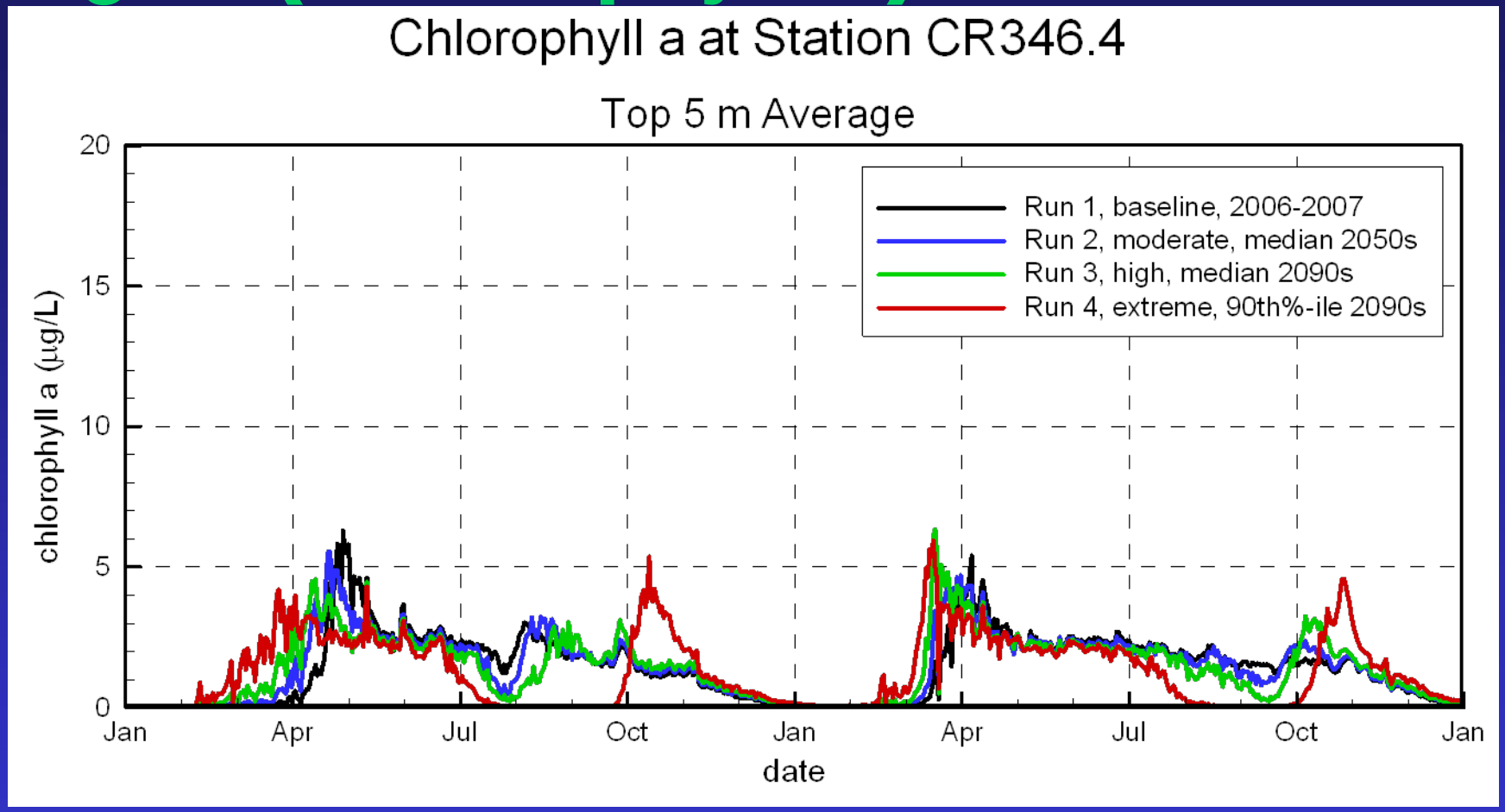
SNWA Intake #3

Change[1] in Average[2] Suspended Solids Concentrations at SNWA Intake #3



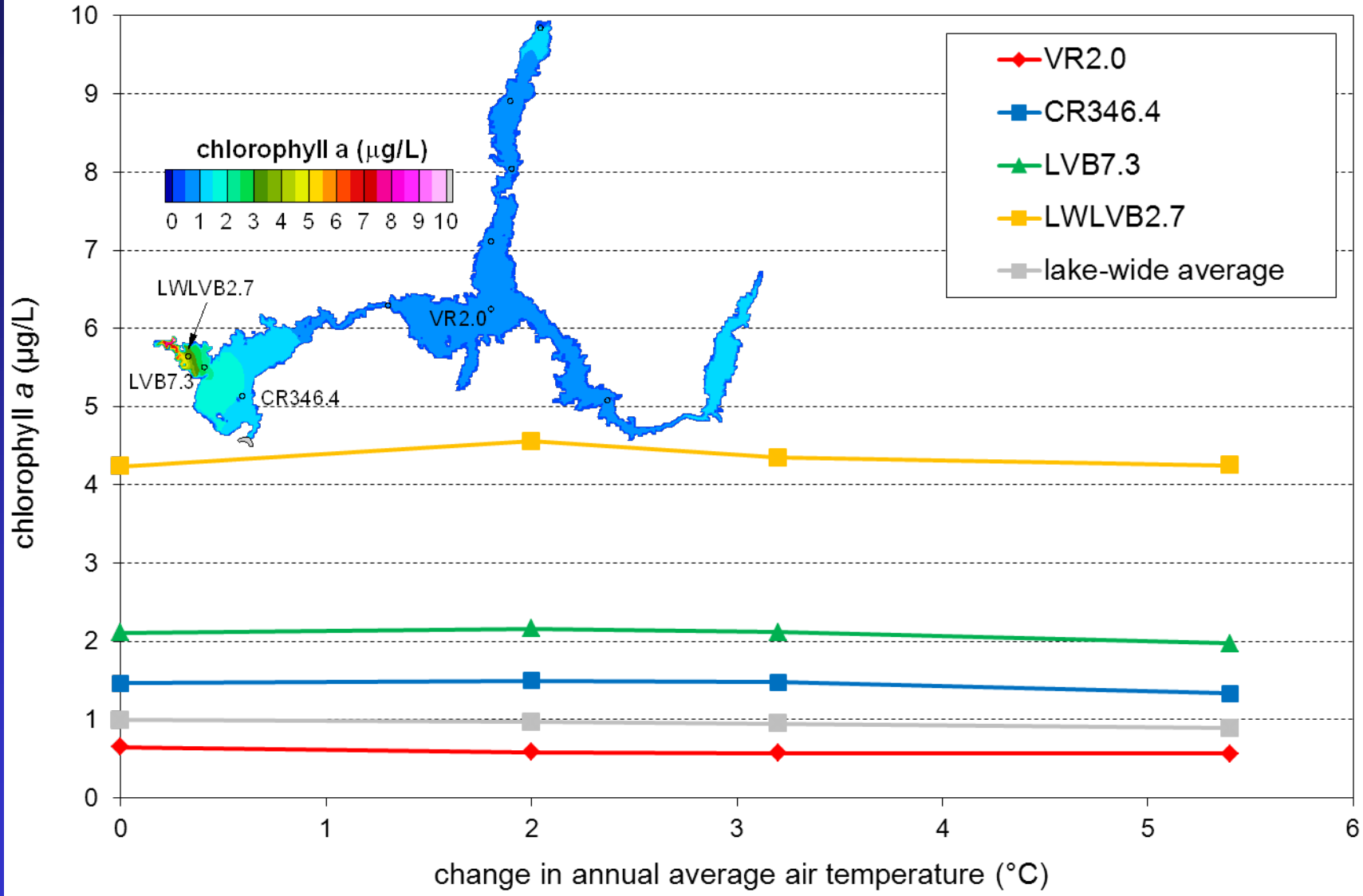
1. Change is percent change in concentration relative to Run 3, WSEL = 1100 ft.
2. Average is annual average for second simulation year.

Algae (Chlorophyll a)

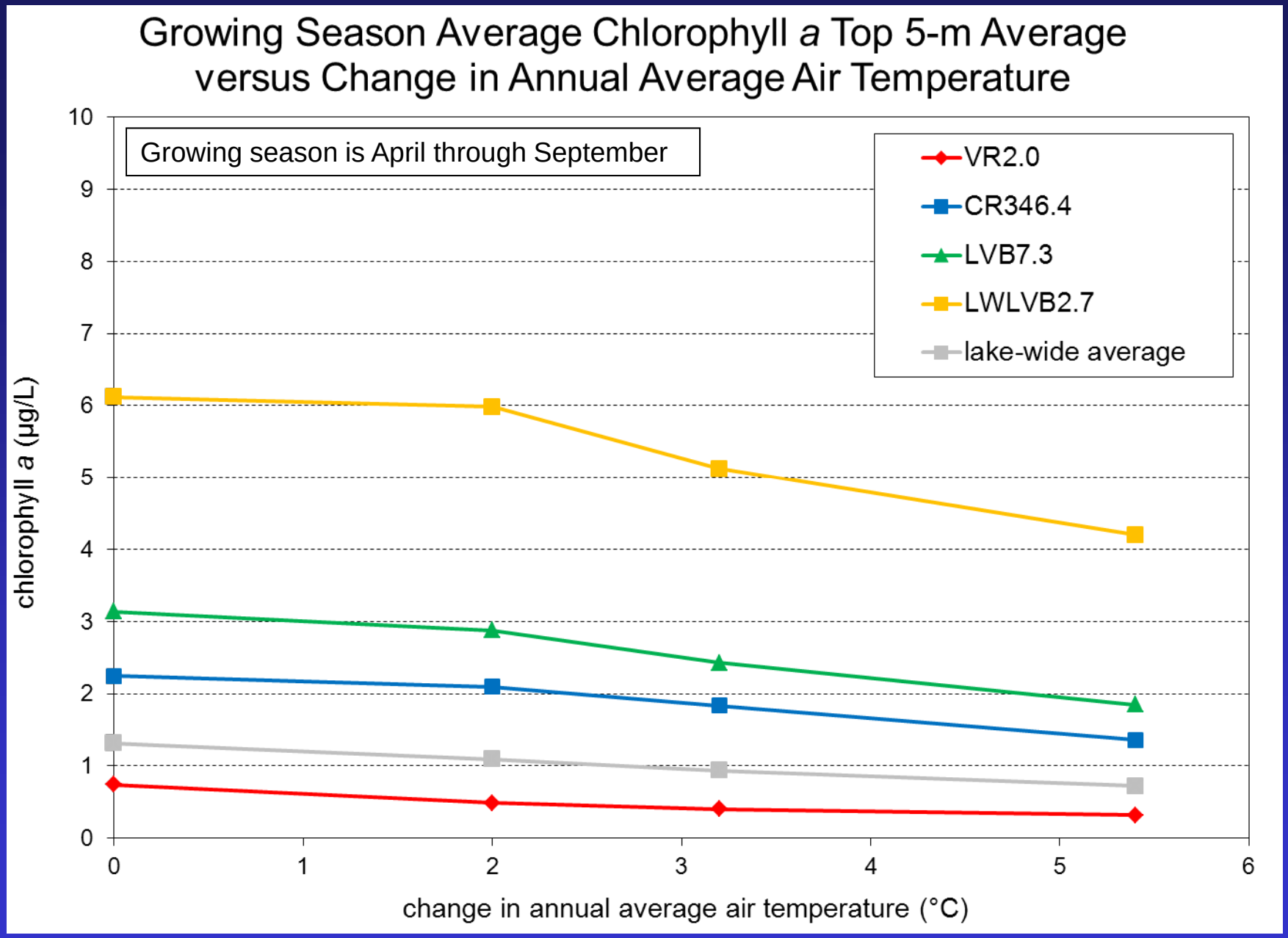


- Algae grows earlier (warmer)
- Less growth in July – September (too warm in summer …)
- Similar peak magnitudes

Annual Average Chlorophyll *a* Top 5-m Average versus Change in Annual Average Air Temperature



Values are for the second simulation year.



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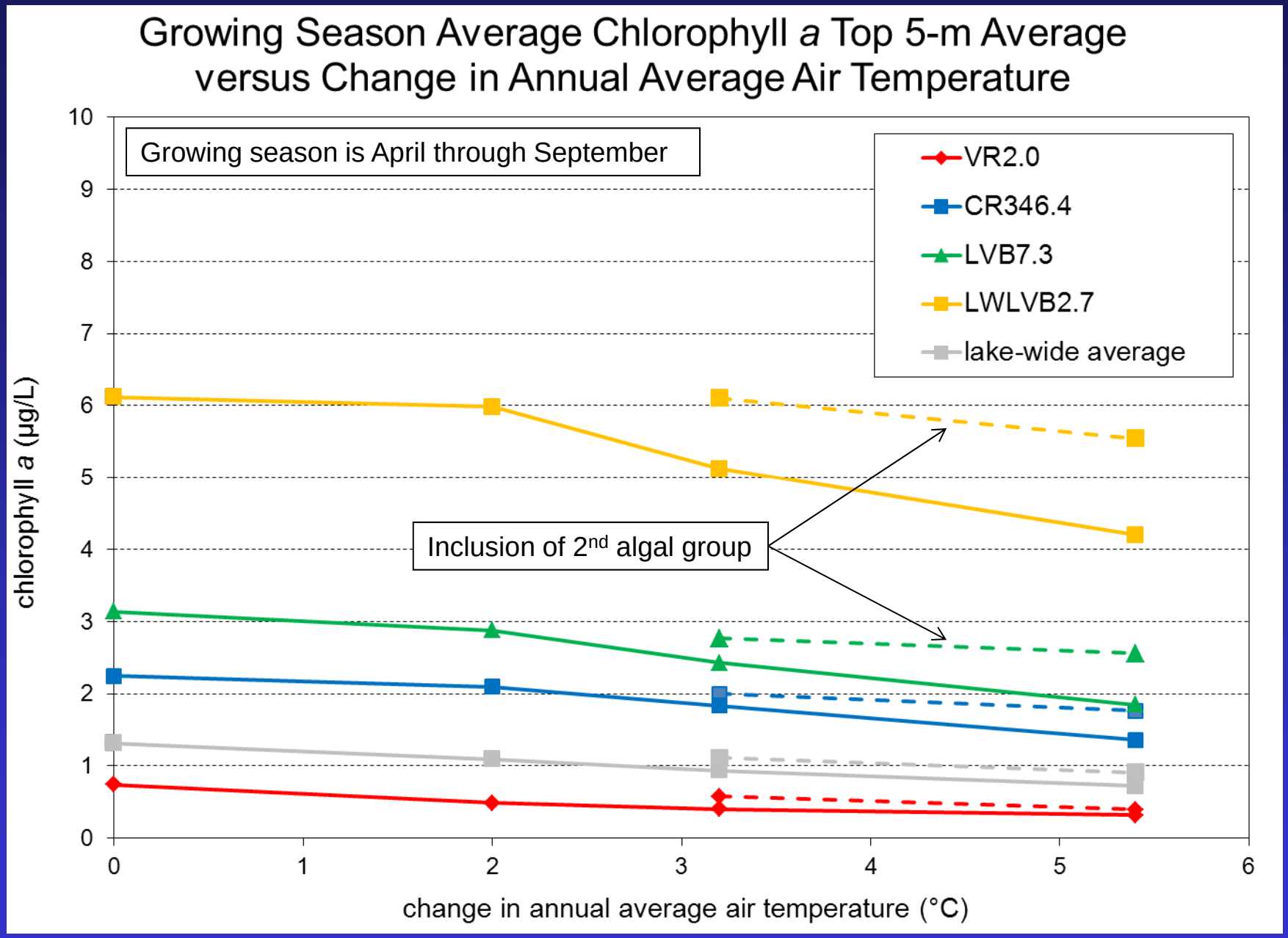
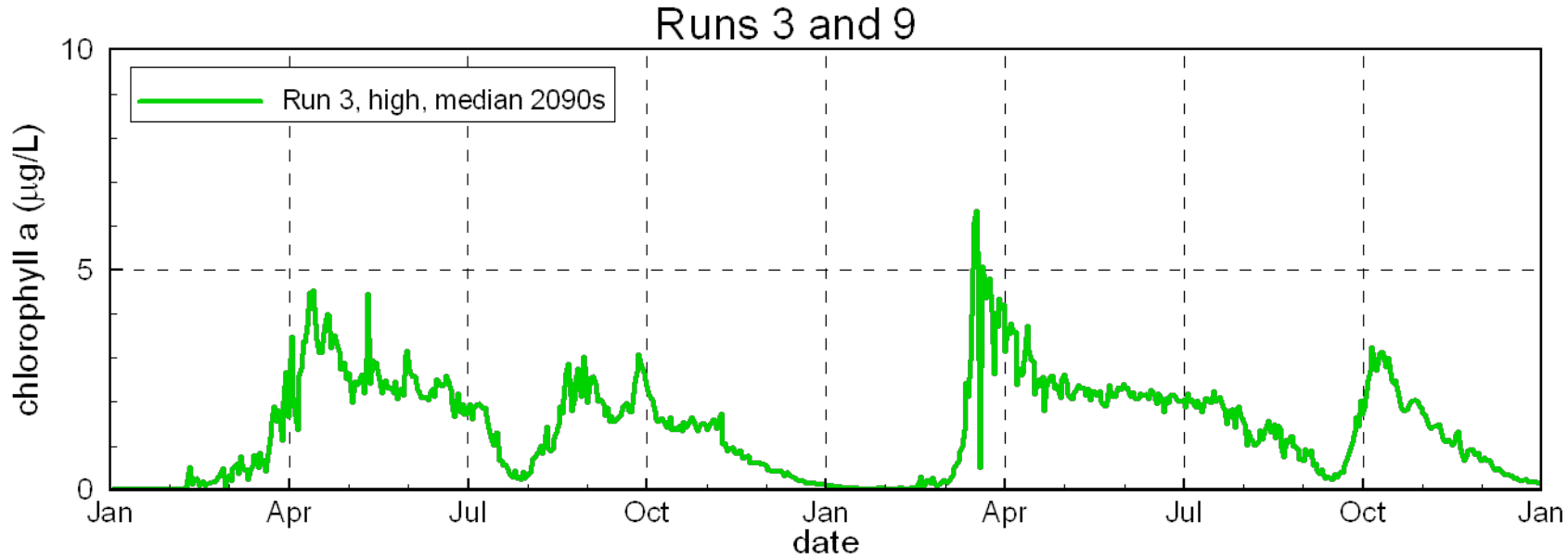
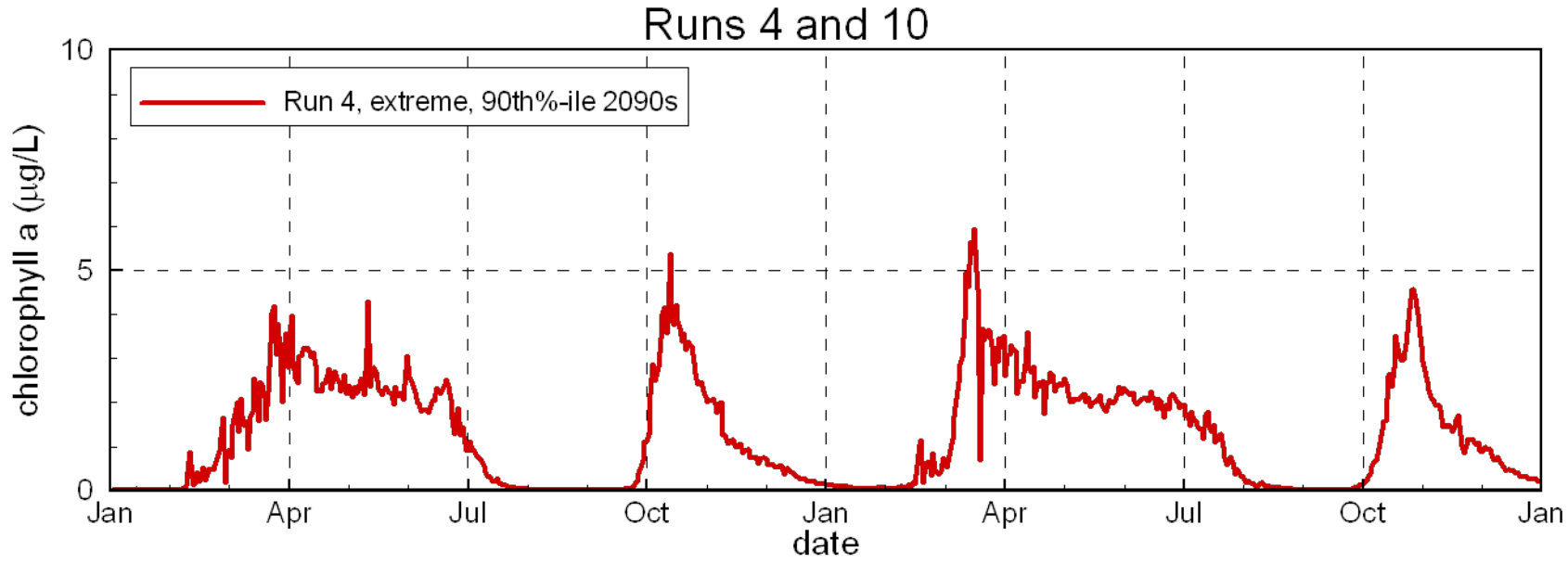


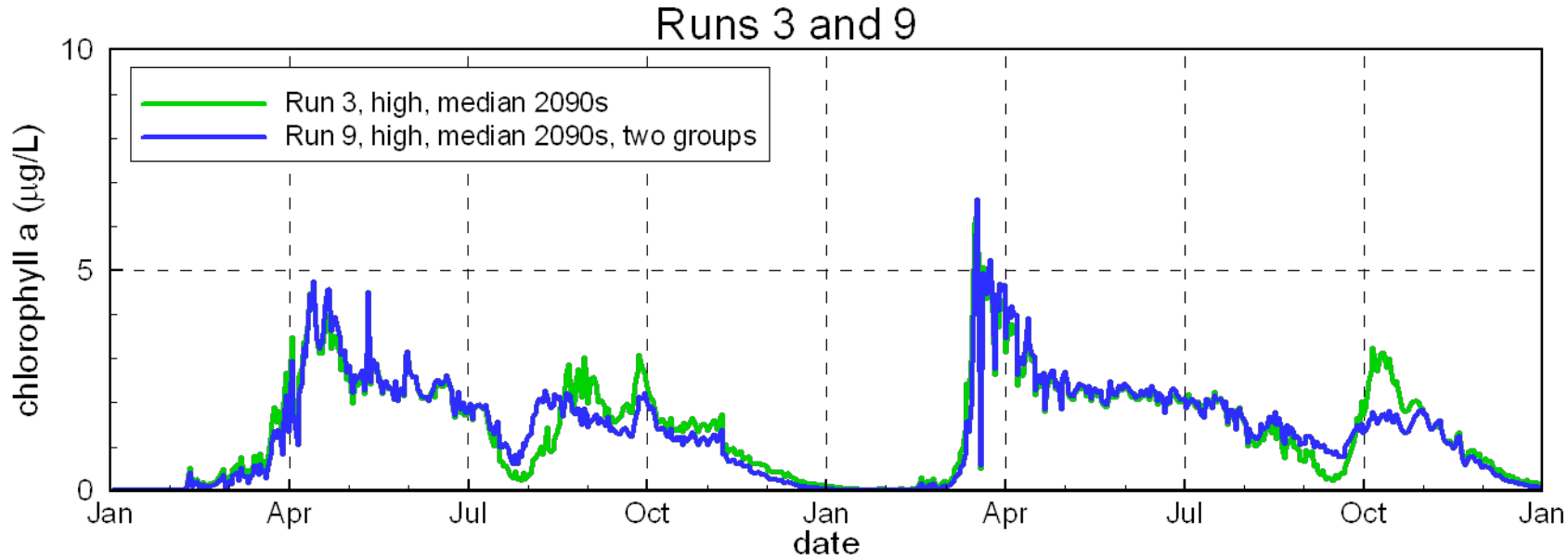
Values are for the second simulation year.

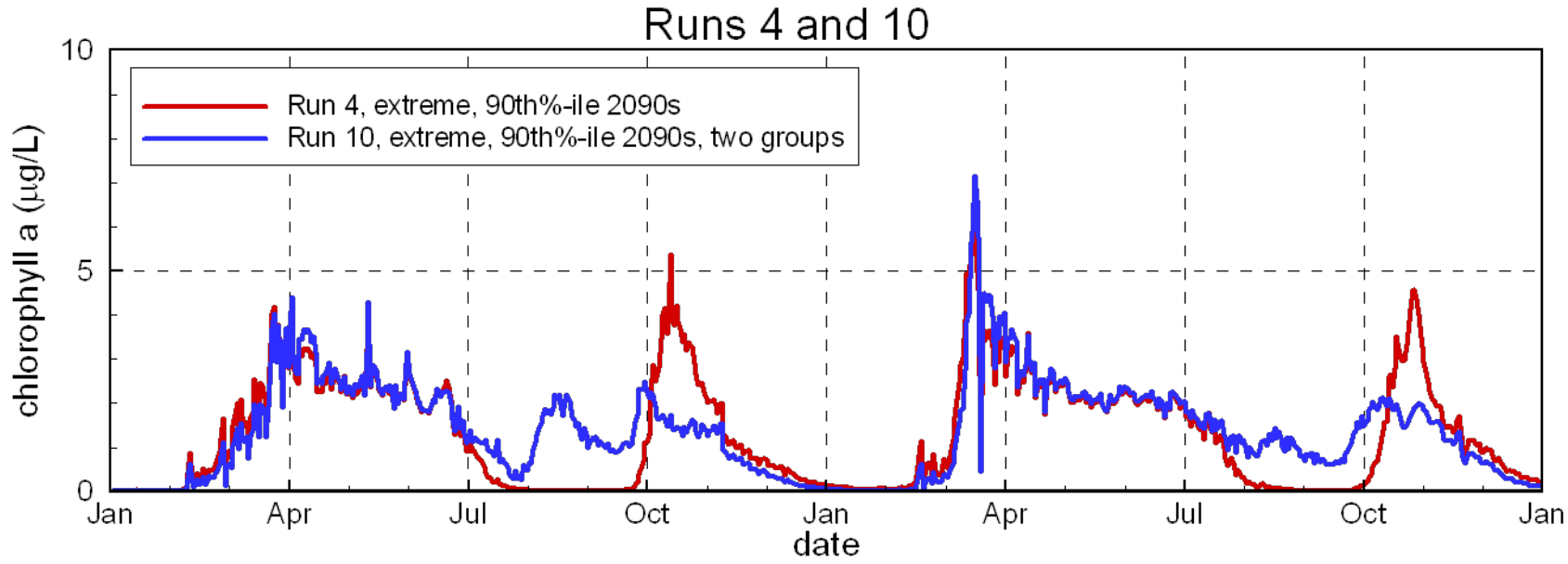
Chlorophyll a at Station CR346.4 (Top 5 m Average)

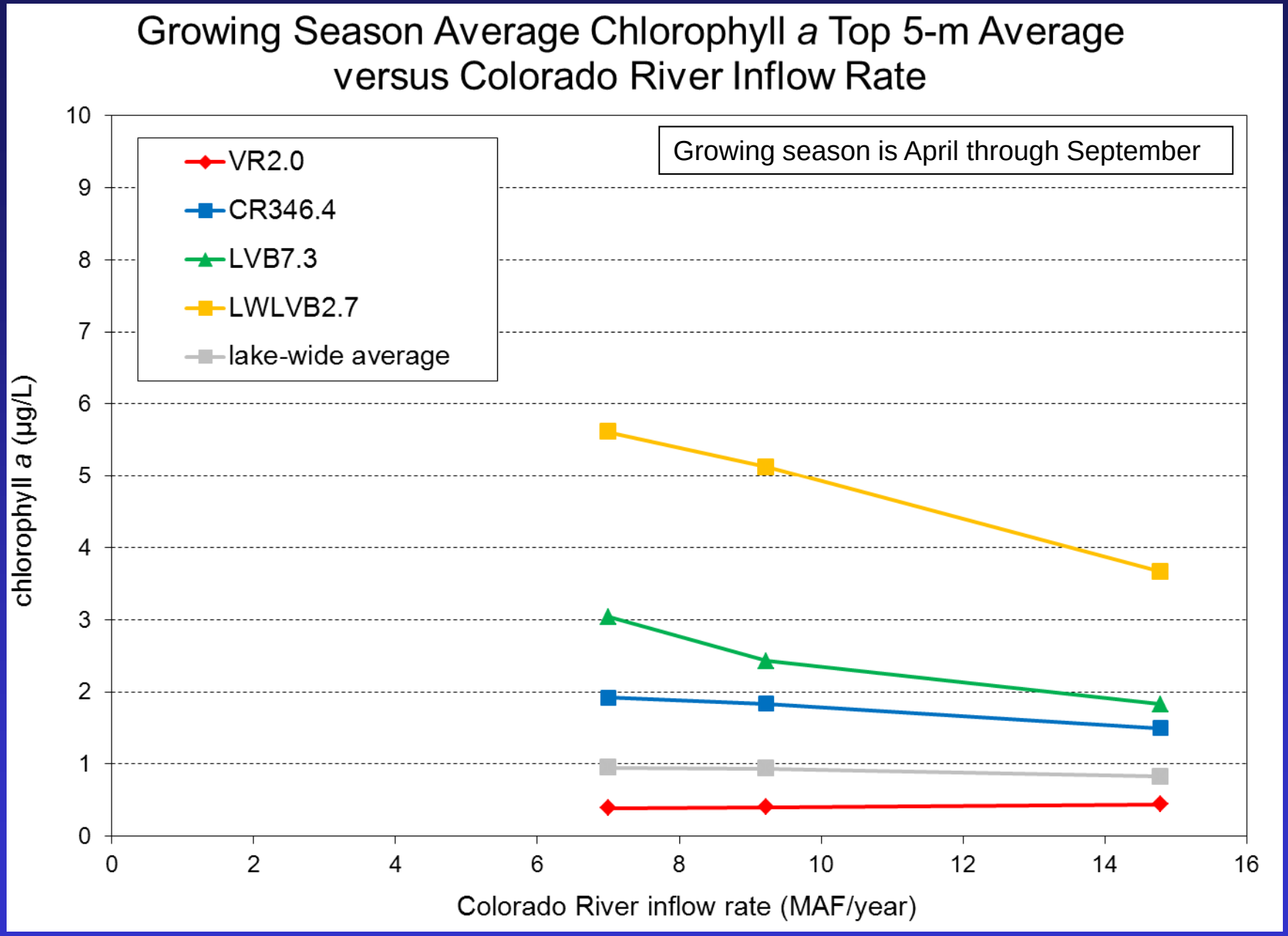




Chlorophyll a at Station CR346.4 (Top 5 m Average)

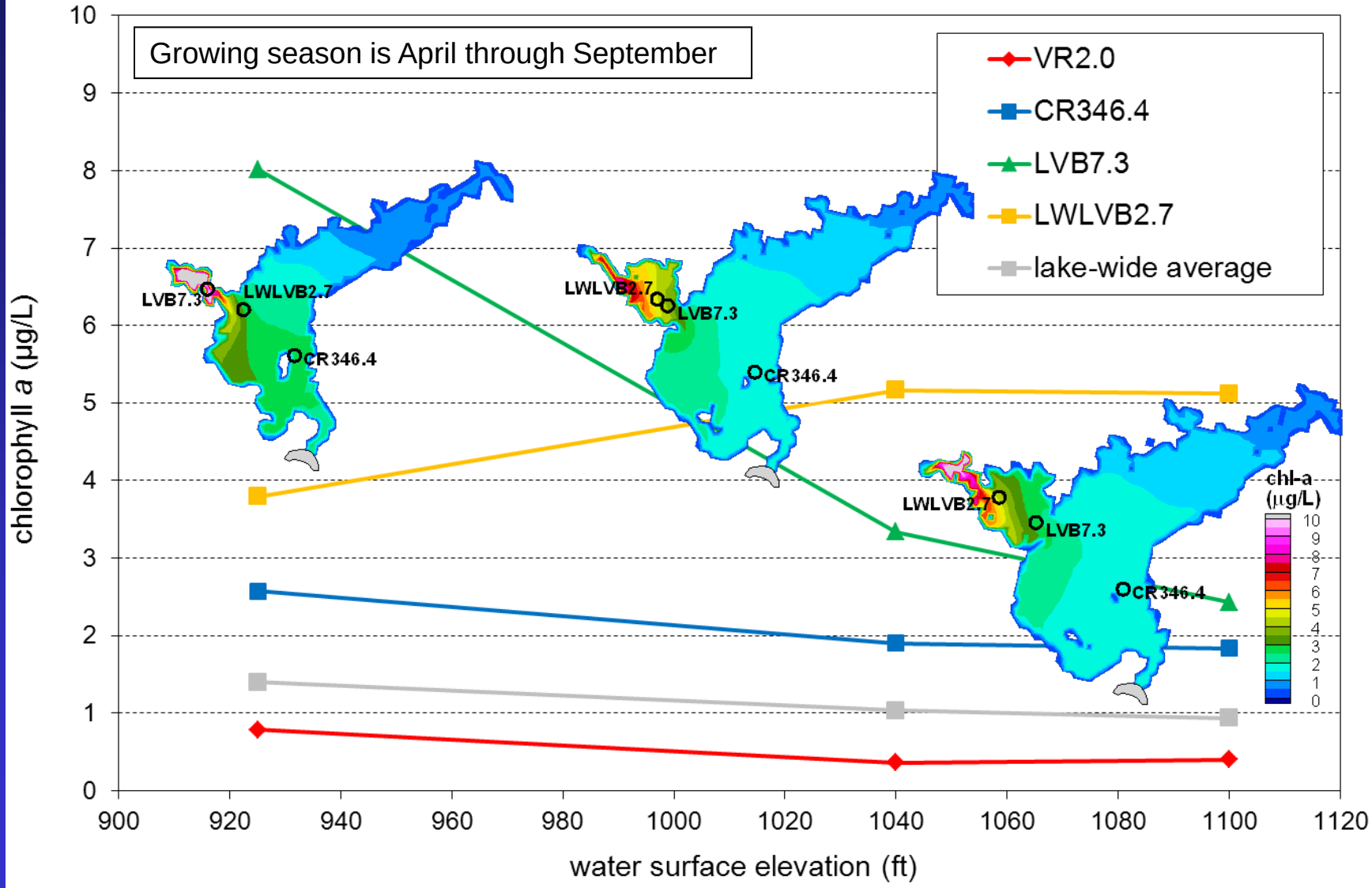






Values are for the second simulation year.

Growing Season Average Chlorophyll *a* Top 5-m Average versus Water Surface Elevation



Values are for the second simulation year.

Conclusions

- **Warmer air temperatures**
  - Water temperature increases
  - Increased stratification
  - Decreased DO concentrations
- **Hoover Dam effect**
  - Withdrawals from epilimnion
- **Lower WSELs**
  - Higher suspended-solids concentrations
  - Higher water temperatures, bromide, and TOC concentrations at SNWA Intake #3

Conclusions – Algae

- **Warmer temperatures**
  - Algae growth begins up to one month earlier
  - Annual average concentrations remain approximately the same (P-limited)
  - Growing season average concentrations <u>may</u> decrease
  - Algae will likely adapt (shift in species)

- **Concentrations increase as a result of**
  - Lower WSEL
  - Lower Colorado River inflow rate

- **More research on algae species**

Acknowledgements

- **U.S. Bureau of Reclamation**
- **Southern Nevada Water Authority**
- **Clean Water Coalition**
  - City of Las Vegas
  - City of Henderson
  - City of North Las Vegas
  - Clark County Water Reclamation District

Questions

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