CASCaDE

Computational Assessments of Scenarios of Change for the Delta Ecosystem

Noah Knowles
presenting for the
CASCaDE
Team

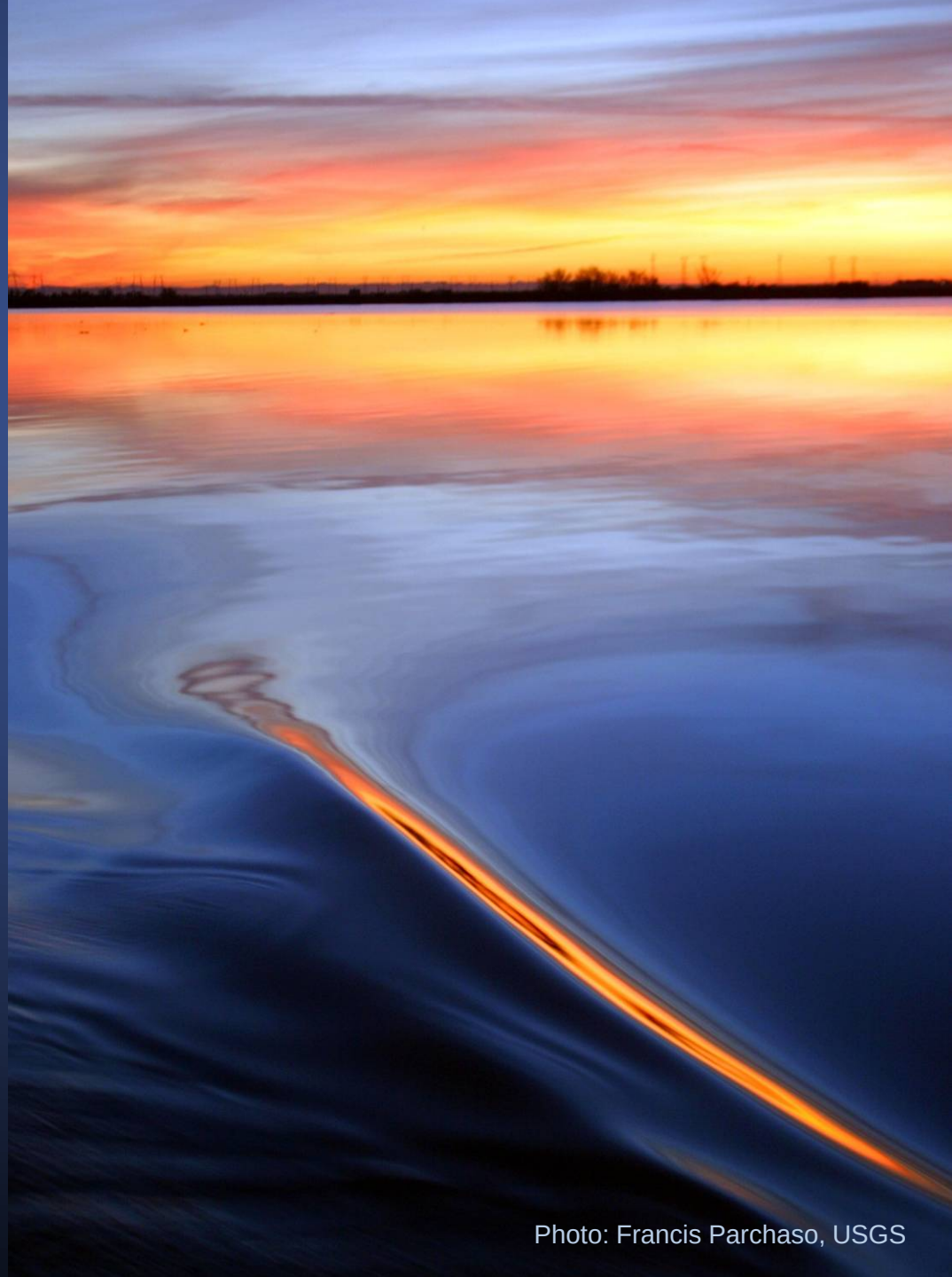
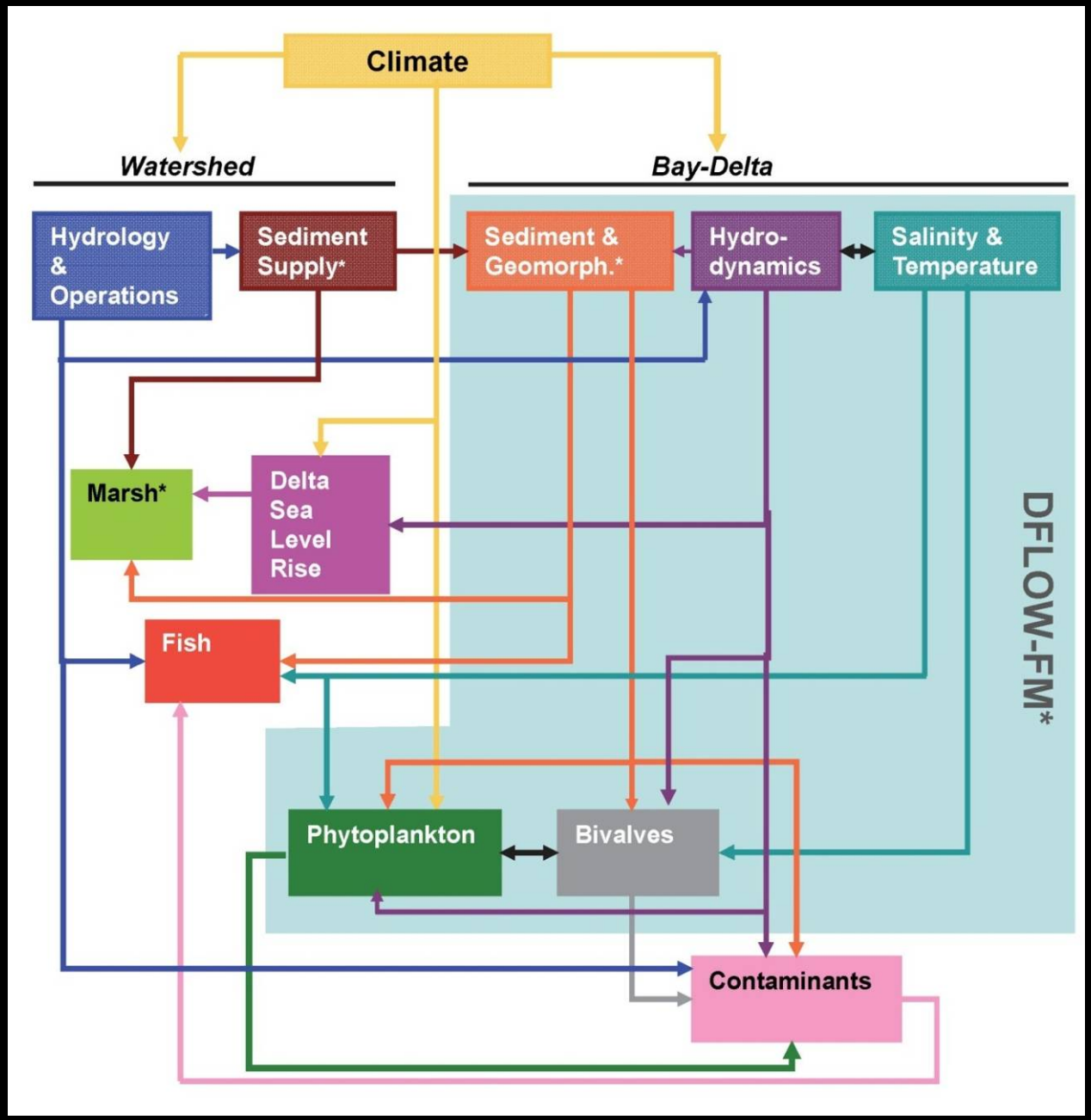


Photo: Francis Parchaso, USGS

CASCaDE:

Linked modeling framework to evaluate Delta responses to multiple forces of change

- **>30 scientists**
- **4 USGS Offices**
- **4 Universities**
- ***Cooperators*: Deltares, DWR, USBR**
- **Funded by USGS, Delta Science Program**



CASCaDE 1

(2006-2010)

Primary Forcing: Climate

OPEN ACCESS Freely available online PLoS one

Projected Evolution of California's San Francisco Bay-Delta-River System in a Century of Climate Change

James E. Cloern[1*], Noah Knowles[1], Larry R. Brown[2], Daniel Cayan[3], Michael D. Dettinger[3], Tara L. Morgan[2], David H. Schoellhamer[2], Mark T. Stacey[4], Mick van der Wegen[5], R. Wayne Wagner[4], Alan D. Jassby[6]

Available through cascade.wr.usgs.gov

CASCaDE 2

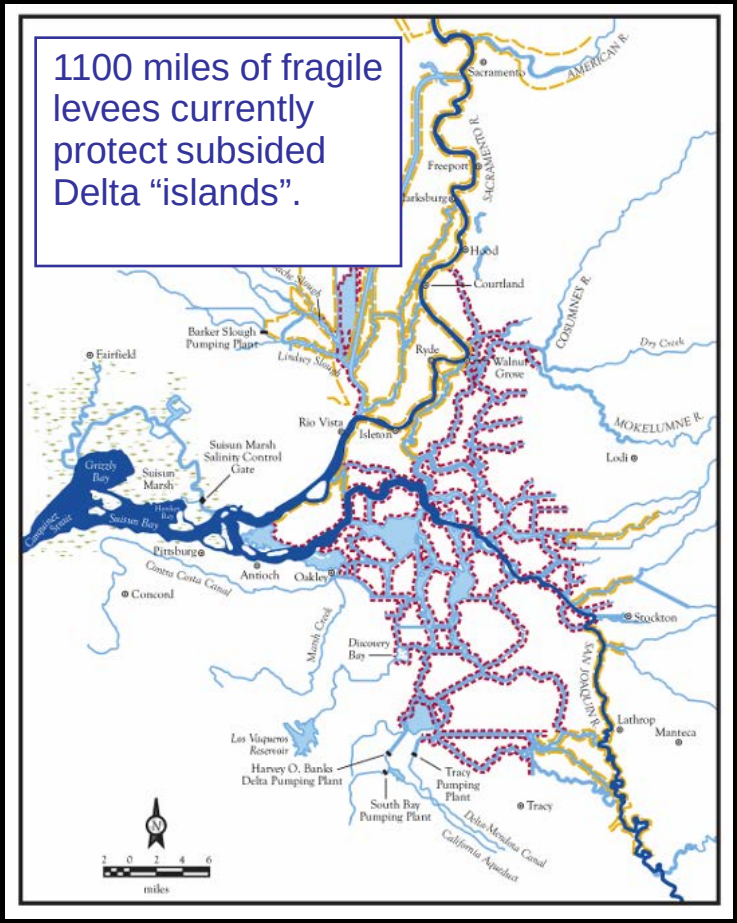
(2011-present)

Forcing: Climate
+ Physical
configuration

(and refined, expanded modeling capabilities)

Physical Configuration Scenarios

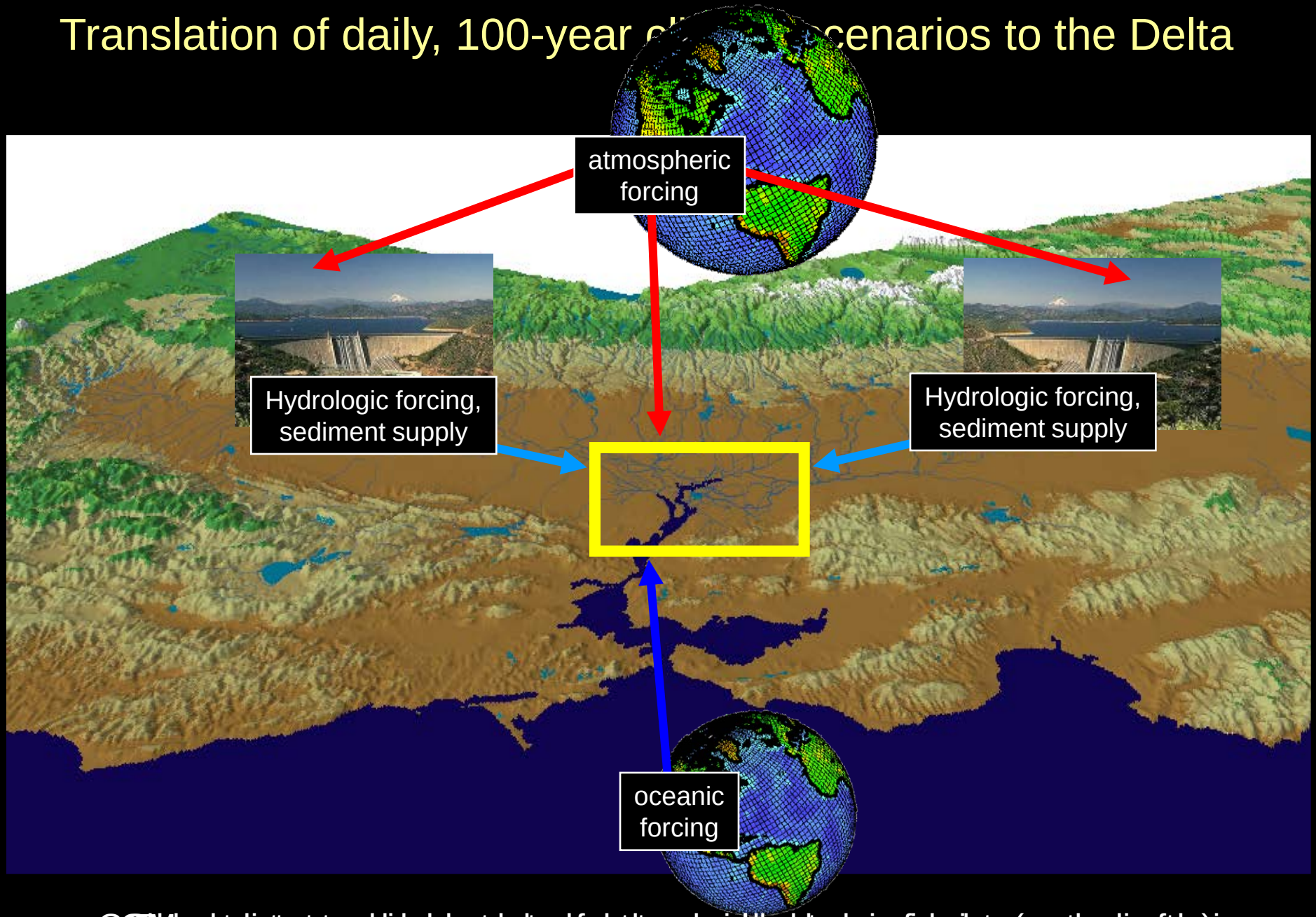
Multiple Flooded Islands



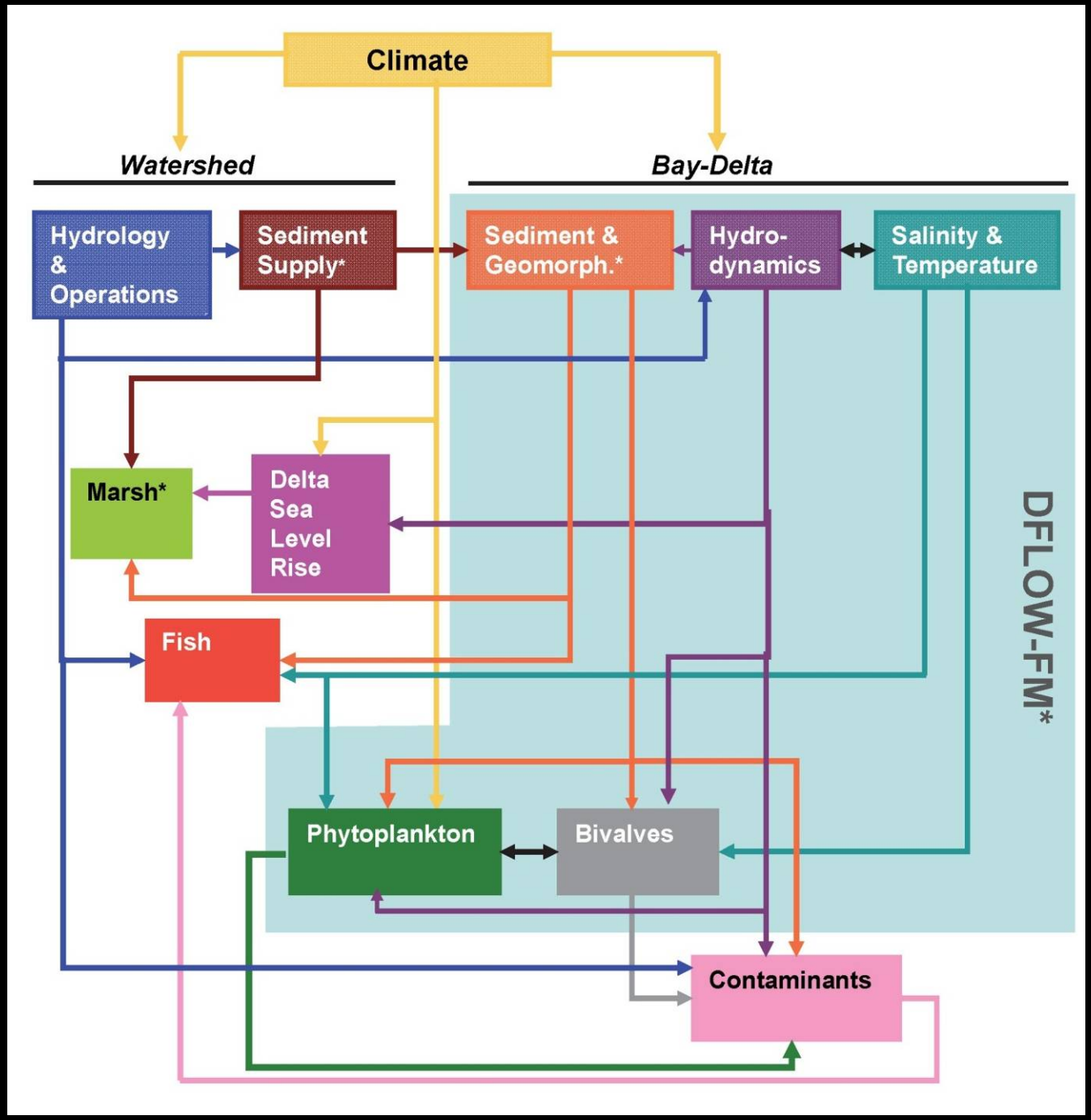
Alternative Conveyance

Also possibly: Ecosystem Restoration

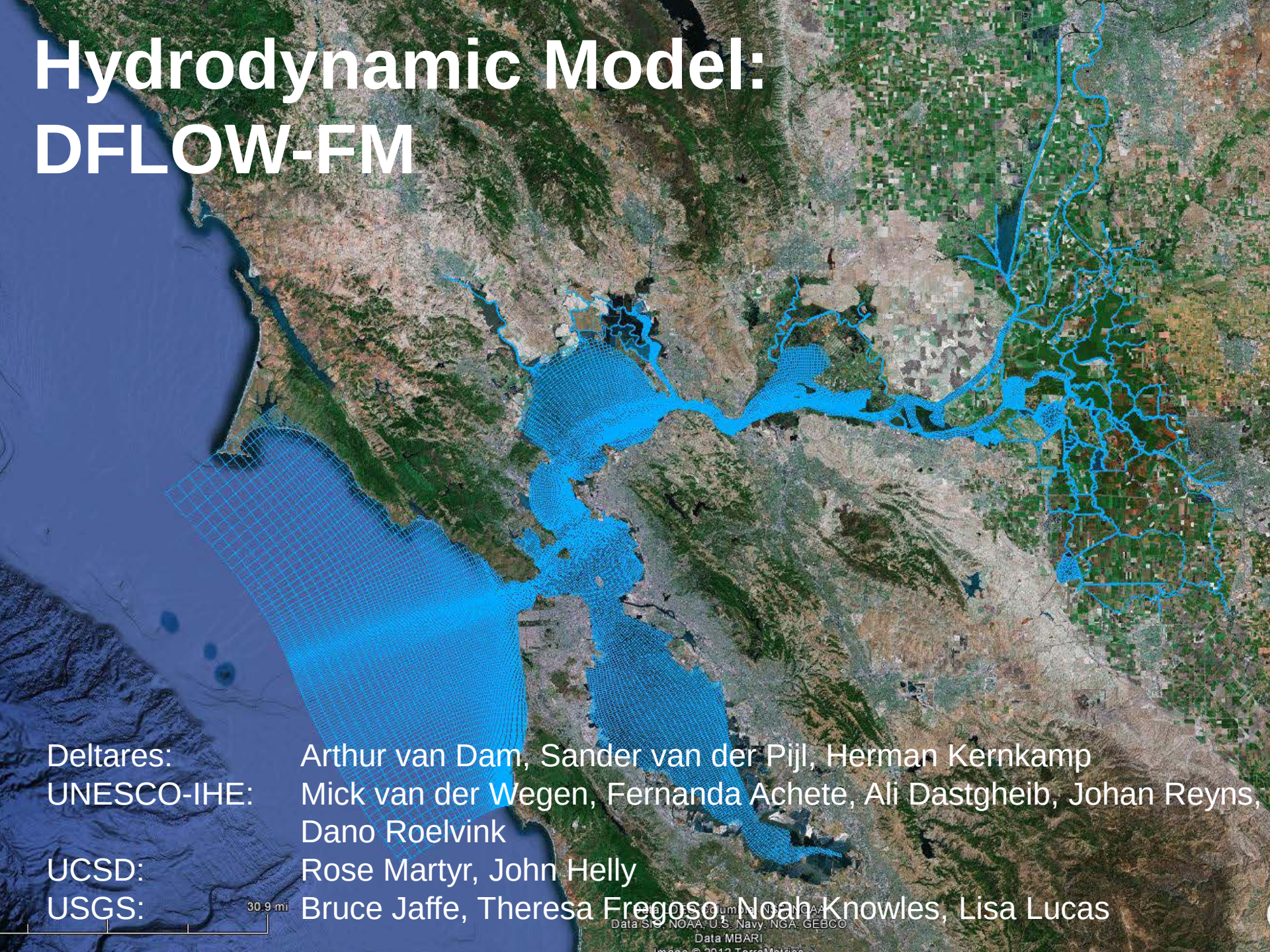
Translation of daily, 100-year climate scenarios to the Delta



GCM outputs are used to develop forcing (weather) for the hydrodynamic models of the Delta.


Climate
Watershed
Bay-Delta
Hydrology & Operations
Sediment Supply*
Sediment & Geomorph.*
Hydro-dynamics
Salinity & Temperature
Marsh*
Delta Sea Level Rise
Fish
Phytoplankton
Bivalves
Contaminants
DFLOW-FM*

Hydrodynamic Model: DFLOW-FM



Deltares: Arthur van Dam, Sander van der Pijl, Herman Kernkamp
UNESCO-IHE: Mick van der Wegen, Fernanda Achete, Ali Dastgheib, Johan Reyns, Dano Roelvink
UCSD: Rose Martyr, John Helly
USGS: Bruce Jaffe, Theresa Fregoso, Noah Knowles, Lisa Lucas

Bathymetry grid

(Mick van der Wegen, Bruce Jaffe, Theresa Fregoso)

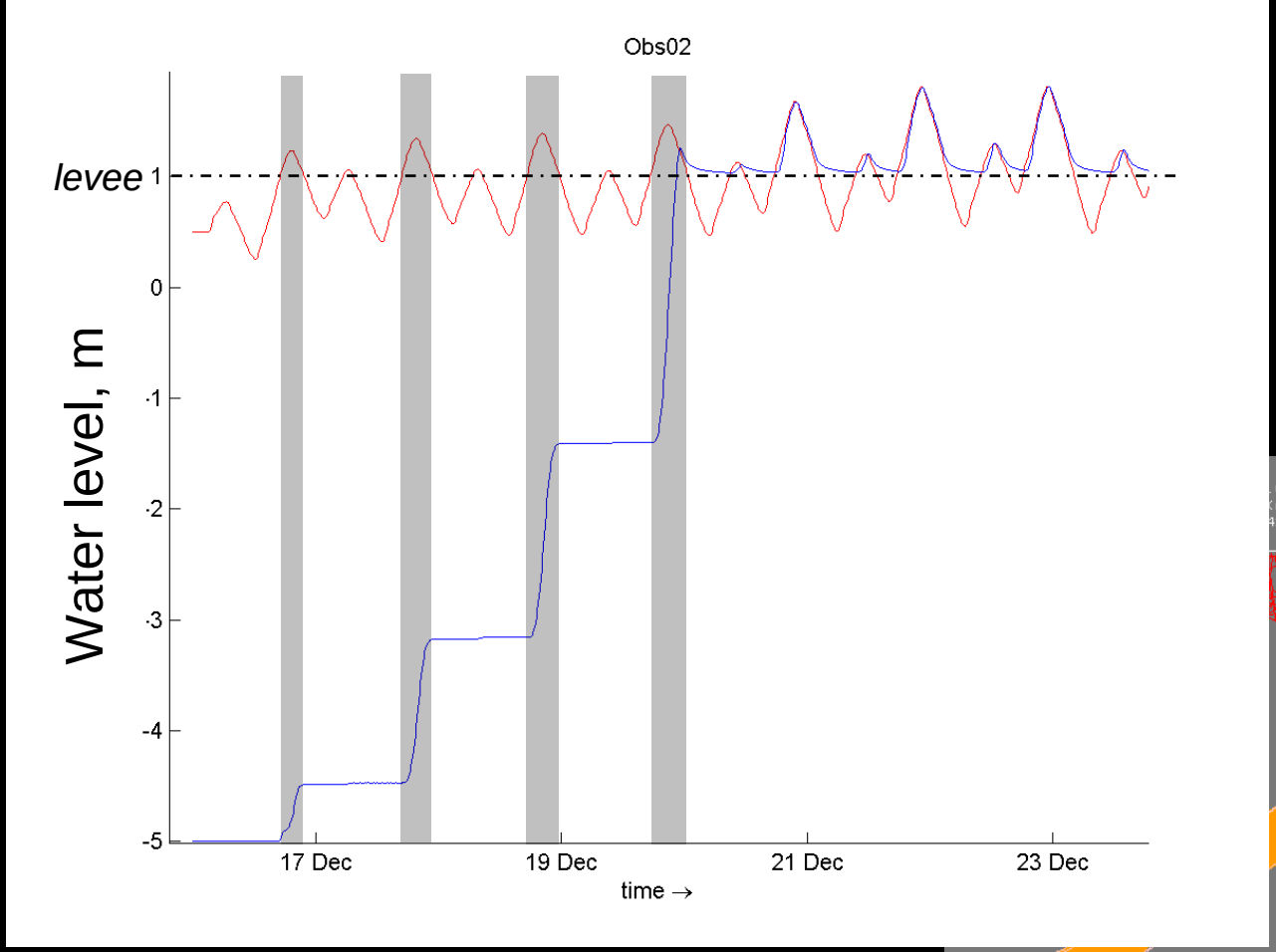
Courtesy Mick van der Wegen

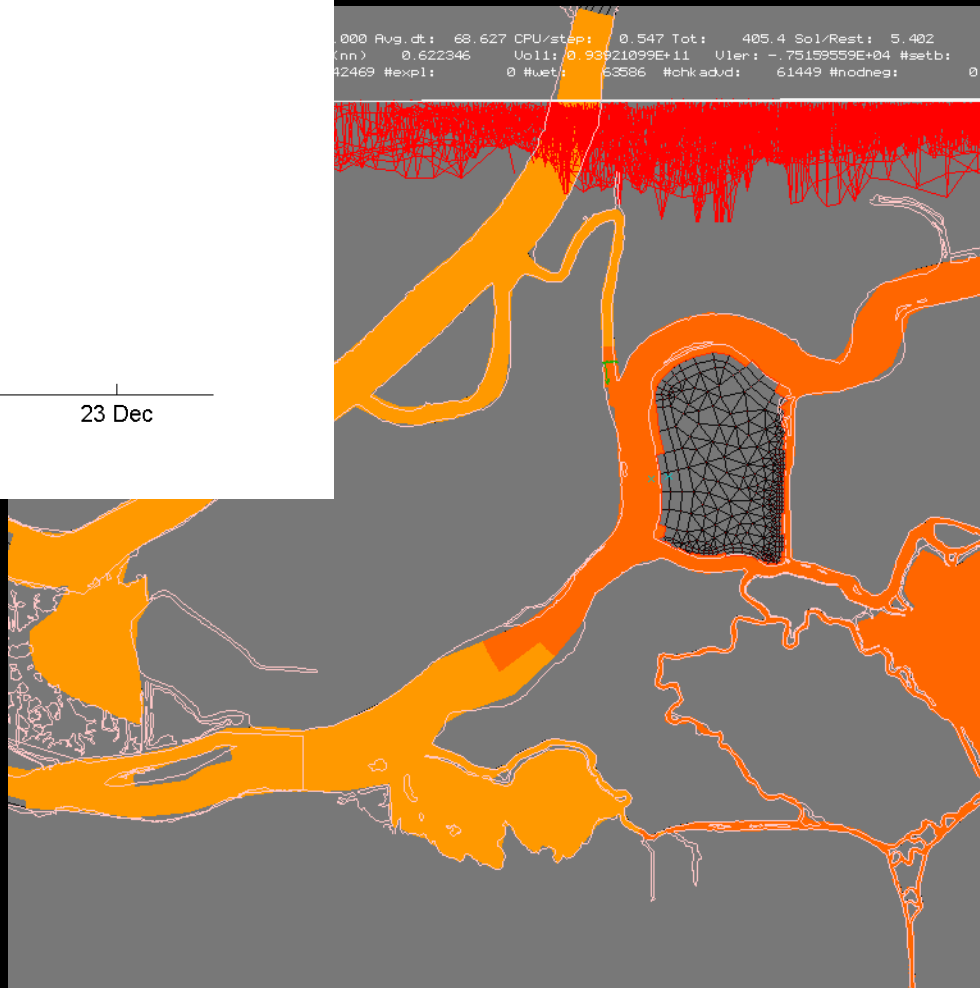
In progress: Seamless Bathy-Topo (LIDAR) grid

(Mick, Bruce, Theresa)

Courtesy Mick van der Wegen

Levee Overtopping & Filling of an Island





red line: level in river

blue line: level in island

levee height is 1 m

Courtesy Mick van der Wegen, UNESCO-IHE

SDSC's "Gordon" Supercomputer

SDSC
SAN DIEGO SUPERCOMPUTER CENTER

UCSD

University of California, San Diego

"...can process data-intensive problems about 10 times faster than other supercomputers because it employs massive amounts of flash-based memory..."

UCSD—Rose Martyr, John Helly
Deltares—Arthur van Dam, Sander van der Pijl
USGS-NRP—Noah Knowles)

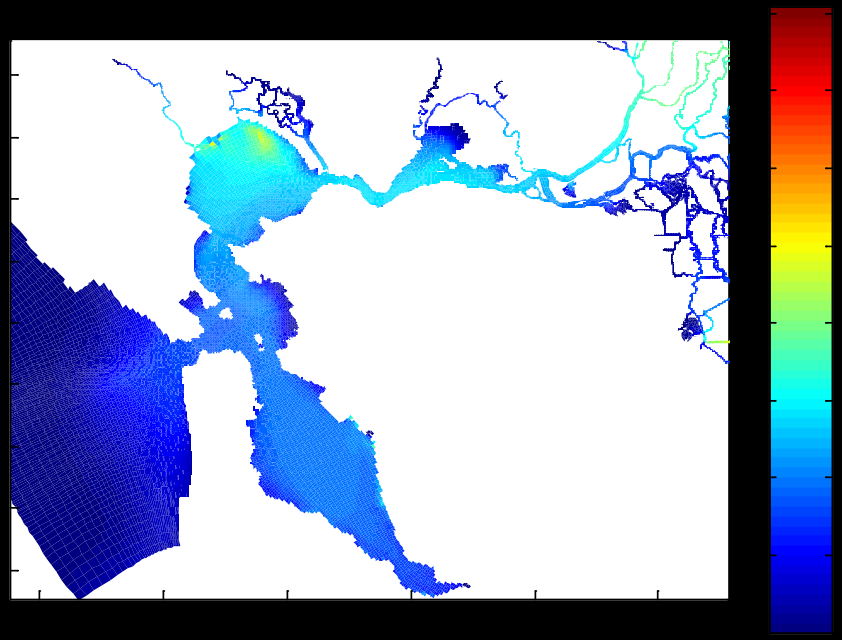
Bay-Delta Suspended Sediment and Geomorphology

UNESCO-IHE (Delft):

Mick van der Wegen, Fernanda Achete-Minikowski, Dano Roelvink

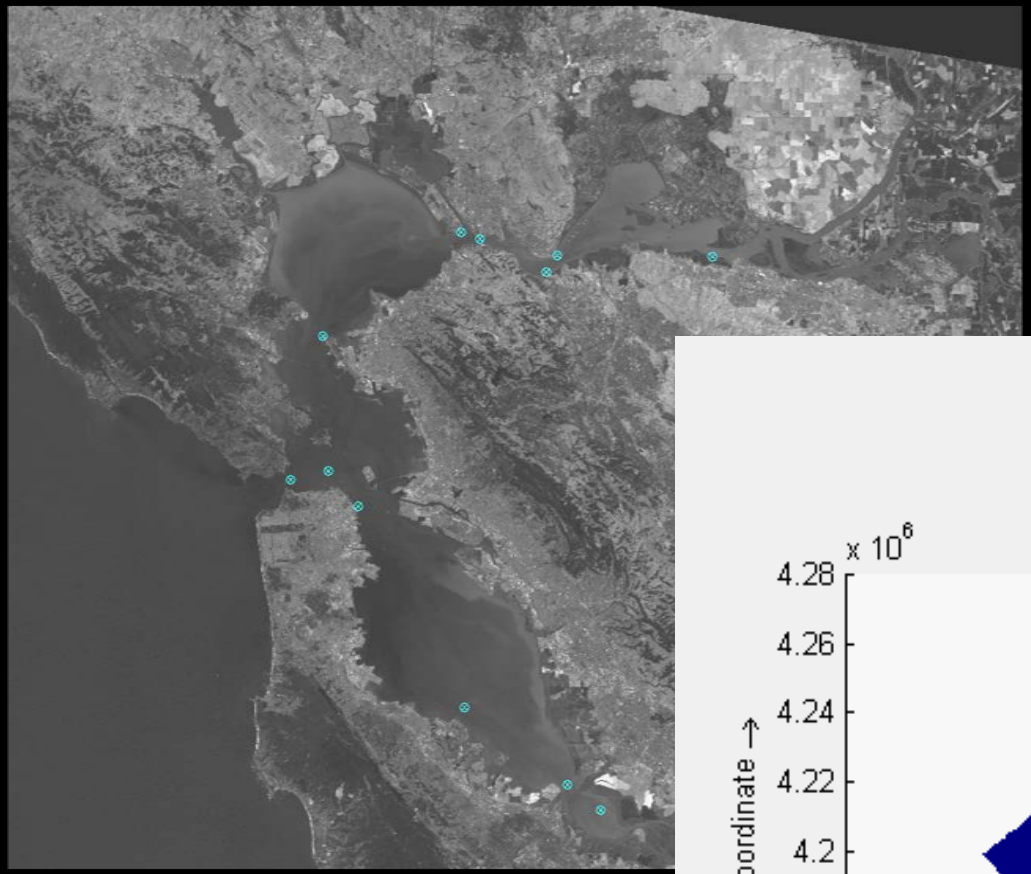
USGS-CMG (Santa Cruz): Bruce Jaffe

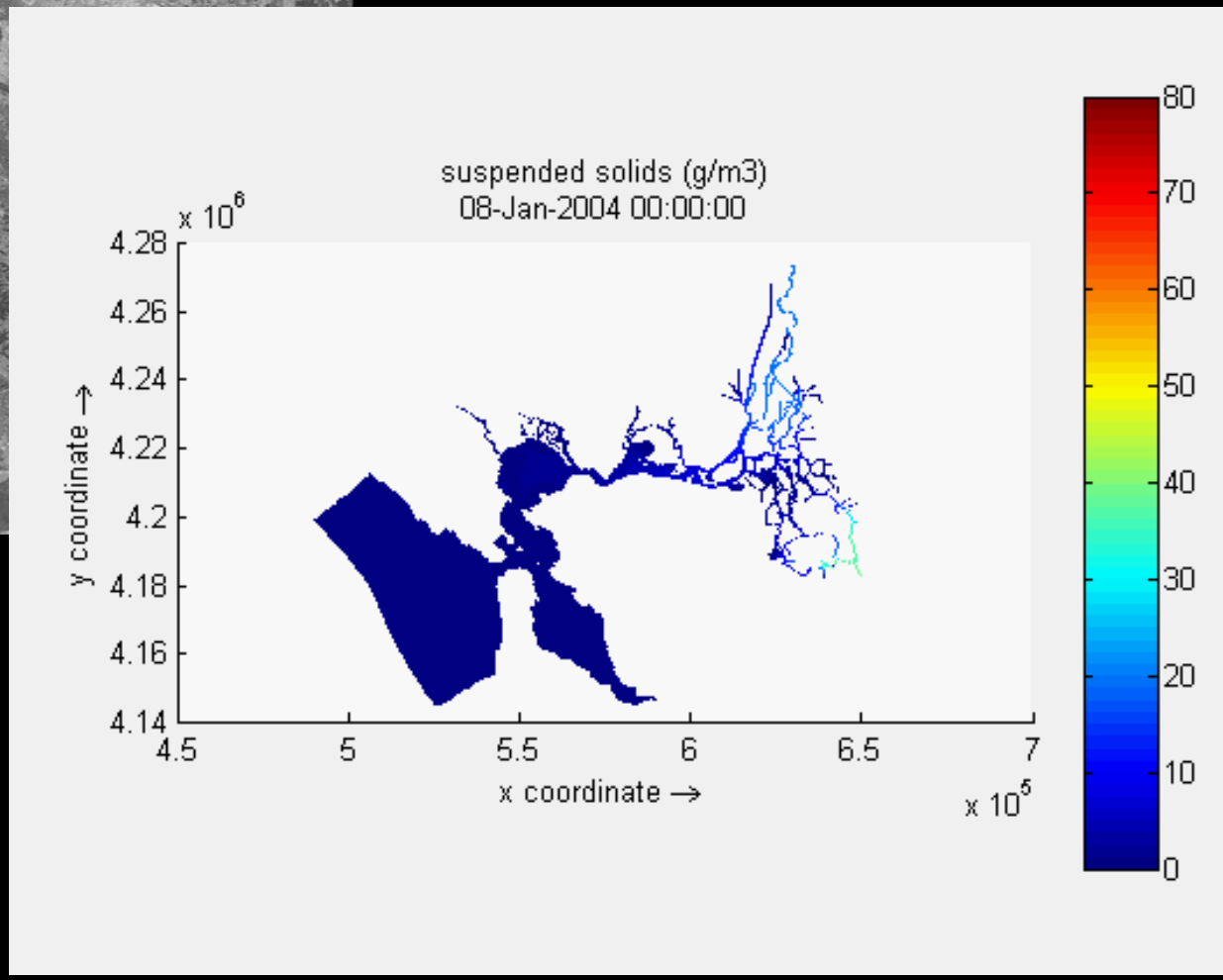
Suspended Solids Concentration mg/L



Purpose: To project future suspended sediment concentrations and long-term changes in geomorphology

Suspended Sediment Concentration [mg/L]



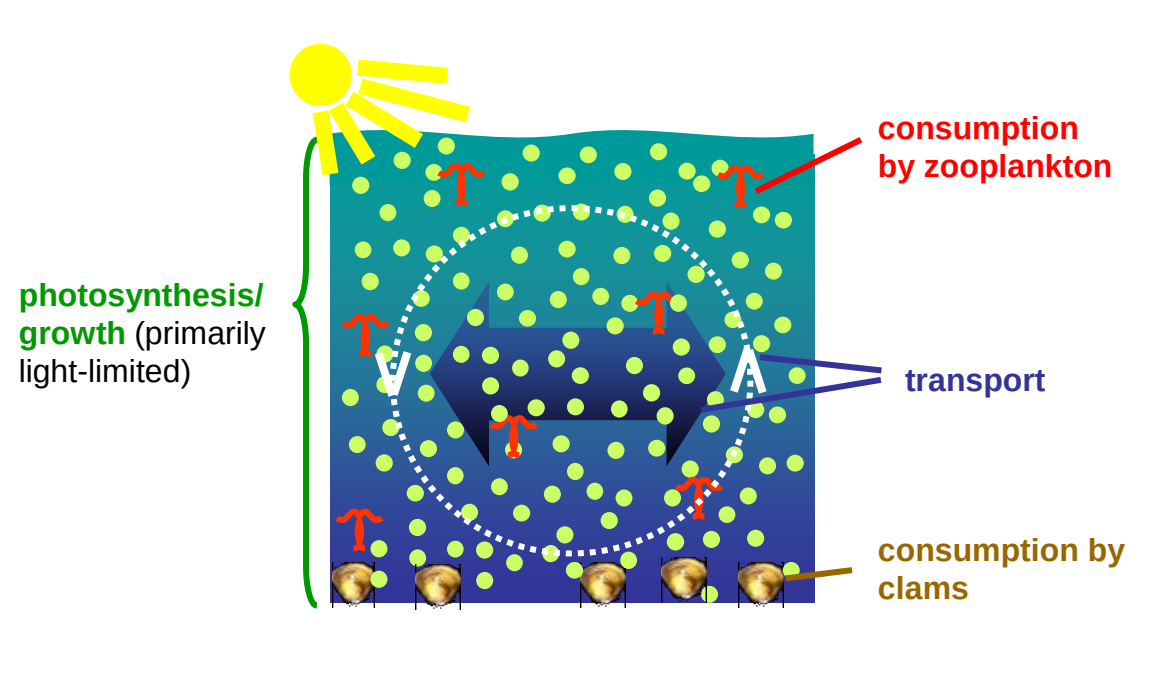


Courtesy Fernanda Minikowski-Achete

Phytoplankton

Lisa Lucas (USGS-NRP)
Wim Kimmerer (San Francisco State Univ.)
Hans Los (Deltares)

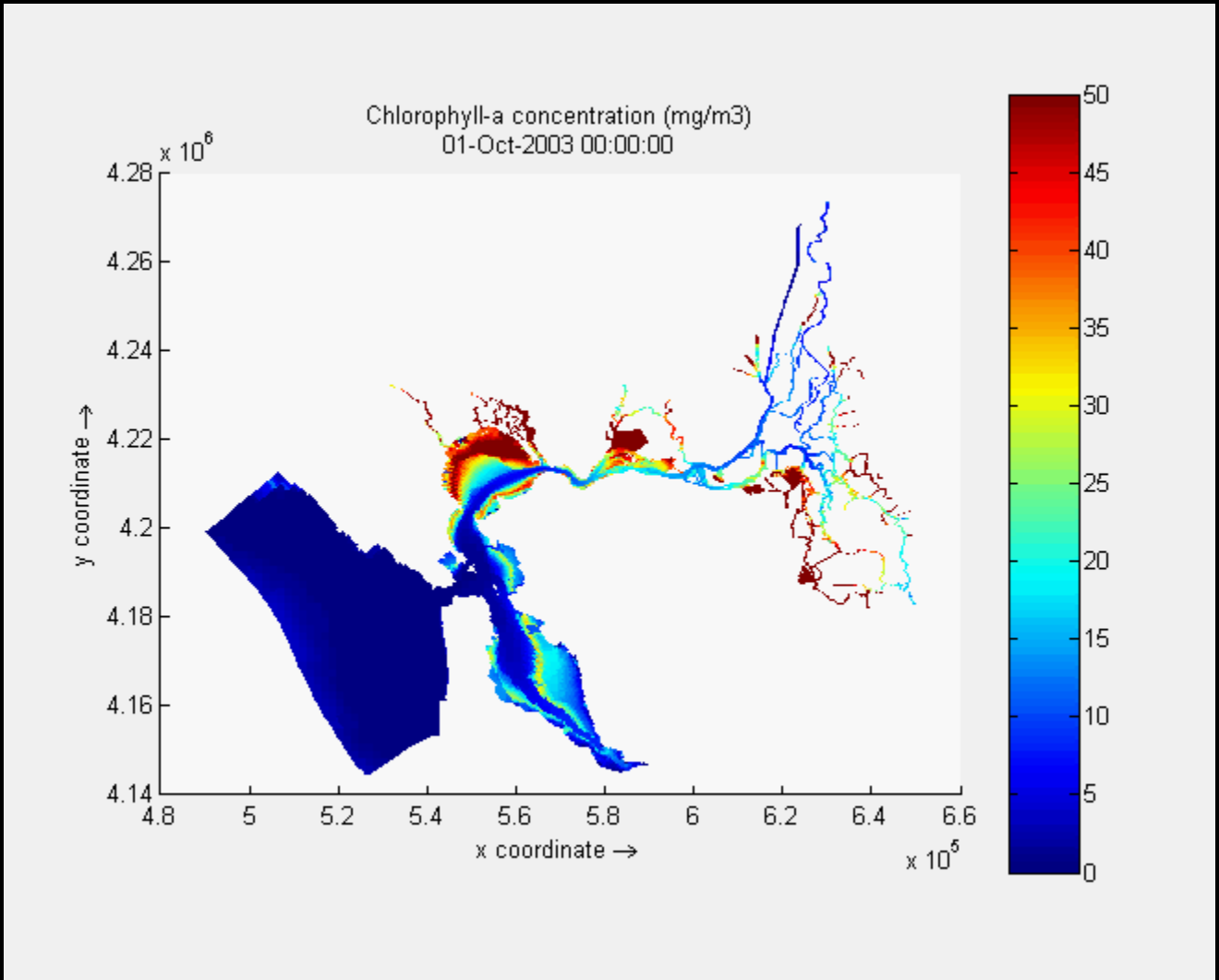
How might phytoplankton biomass and productivity in the Delta change in response to changing climate & physical configuration?



Inputs: solar irradiance, turbidity, clam grazing rates, zooplankton grazing rates, velocity/stage/turbulent diffusivity, flow & temp @ boundaries

Outputs: algal biomass to clam, contaminant, fish models

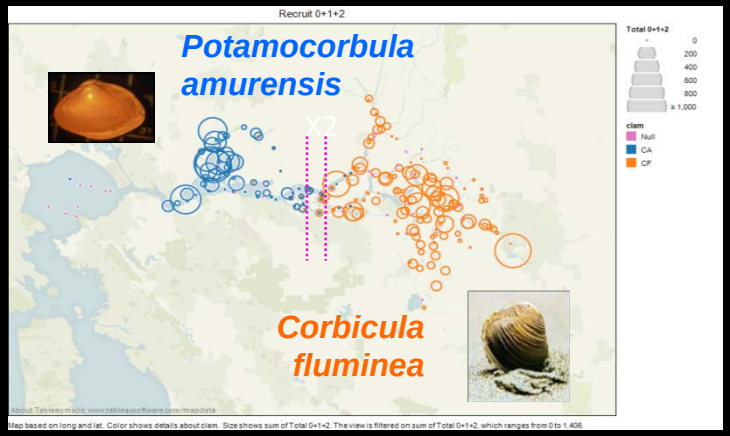
Phytoplankton properly talking to hydrodynamics...



In progress: incorporation of grazing...stay tuned

Non-native Bivalves

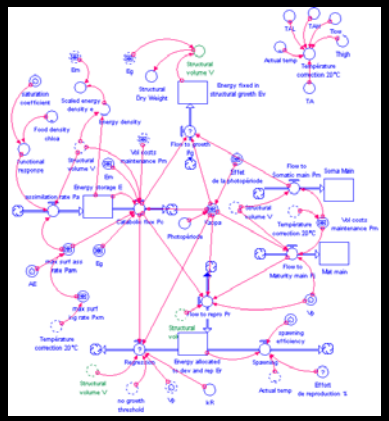
J. Thompson, F. Parchaso (USGS-NRP),
T. Troost (Deltares)



Q: How will clam grazing rates change? (←→phytoplankton model)

Q: How will distributions and biomass change? (→contaminant model)

DEB (Dynamic Energy Budget) Model



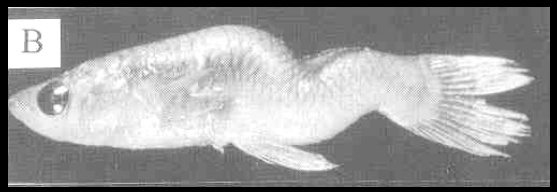
An energetics model grows the bivalves and a population model estimates bivalve biomass distribution

Phytoplankton Model

Contaminant Model

Biomonitor:
Potamocorbula amurensis

Selenium
(EPA priority pollutant)



Sacramento Splittail

Robin Stewart (USGS-NRP)
S. Luoma (UC Davis)

Biodynamic Model *(Lee et al.)*

$$[Se]_{organism} = \frac{uptake_{water} + uptake_{food}}{efflux + growth}$$

Terms of equation depend on:

phytoplankton biomass
phytoplankton species
temperature
dissolved Se concen.
dissolved Se species
hydrology
hydrodynamics
point/distributed loads
turbidity
geochemistry
nutrients
other grazers
organisms species
physiology

How does Se bioaccumulation in the clam and its predators vary with:

- hydrology (e.g. source water contributions, residence time)
- Delta configuration
- suspended sediment
- phytoplankton dynamics

Fish

Larry Brown, Marissa Wulff (USGS-CA WSC)

***Hypomesus transpacificus* (“Delta smelt”)**

Physical habitat defined by:

- salinity
- temperature
- turbidity

CASCaDE 1:

- *Climate change has all 3 habitat parameters heading in the wrong direction for Delta smelt!*

Fish

Larry Brown, Marissa Wulff (USGS-CA WSC)

***Hypomesus transpacificus* (“Delta smelt”)**

Physical habitat defined by:

- salinity
- water temperature
- turbidity

CASCaDE 1:

- *Climate change has all 3 habitat parameters heading in the wrong direction for Delta smelt!*
- *Not yet an integrated, spatially explicit habitat analysis*

CASCaDE 2:

- *Integrated, spatially detailed estimates of habitat areas using overlap of continuous salinity, turbidity, and temperature*
- *Infrastructural + climate change*

Summary

- CASCaDE is an interdisciplinary modeling effort aimed at helping illuminate plausible futures for the Delta ecosystem as a function of changing climate and physical infrastructure.
- It takes:
  - *decades of data and knowledge building*
  - *a (good-sized) village*
  - *generous colleagues who like working together!*
  - *$$$ (Thanks, USGS-PES & Delta Science Program!)*